Sturbridge Stormwater Pollution Reduction Project

PROJECT NUMBER: 2015-05/604

PREPARED BY:
Central Massachusetts Regional Planning Commission

PREPARED FOR:

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF RESOURCE PROTECTION

AND

US ENVIRONMENTAL PROTECTION AGENCY
REGION 1
MASSACHUSETTS EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS

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Disclaimer/Acknowledgement of Support

This project has been financed partially with Federal Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (the Department) under Section 604(b) of the Clean Water Act. The contents do not necessarily reflect the views and policies of EPA or of the Department, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

Executive Summary

One to two page concise summary of project goals and results.
The Central MA Regional Planning Commission (CMRPC) received assistance from the Massachusetts Department of Environmental Protection under the Federal Clean Water Act Section 604b for water quality assessment and management planning to assist the Town of Sturbridge as well as Old Sturbridge Village in managing stormwater through planning, education and technical assistance.

The project utilized a three tiered-approach: (1) development of a Low Impact Development (LID) Bylaw (2) development of a stormwater education program in partnership with Old Sturbridge Village (OSV), and (3) a feasibility and conceptual design study to assess improvements to the OSV parking lot using LID techniques.

Green Infrastructure and Low Impact Development (LID) techniques reduce stormwater runoff from residential and commercial development and mimic natural site hydrology by storing, infiltrating and recharging stormwater on site. Prior to this project, the Town of Sturbridge did not have a LID Bylaw or regulations, which was identified as a need in the Town's Master Plan. As such, one of the primary goals of this project was to help the Town develop LID regulations.

The second component provided a LID-based education initiative that was implemented at Old Sturbridge Village (OSV), the largest outdoor museum in New England with 260,000 annual visitors. Thirdly, the project worked with OSV on a conceptual drawing/feasibility for the OSV main visitor parking lot. This parking lot has been identified with having existing stormwater runoff issues, and if implemented, these activities will help to lead to better water quality throughout the Town, which drains into the Quinebaug River Watershed.

By working together with project partners, this project successfully coordinated an educational Earth Day event at Old Sturbridge Village, formed a LID work-group committee within the Town of Sturbridge and held four LID work-group meetings, drafted LID regulations for the Town of Sturbridge, held two educational sessions for boards, officials and the public in the Town of Sturbridge, and completed a feasibility study, and conceptual design of stormwater improvements to the OSV main visitor parking lot.

Introduction

Present project goals and strategy with a description of the study area, project partners, and list of final products.

Quinebaug River Watershed

Seventy-six miles long and draining an area of 148 square miles, the Quinebaug River flows through eight miles in Massachusetts including the Town of Sturbridge. Major tributaries include: Leadmine, Hamant, Hobbs and Breakneck Brooks in Sturbridge along with McKinstry Brook, which originates in the Town of Charlton and passes through Sturbridge and Southbridge (2004-2008 Water Quality Assessment Report).

The watershed is heavily forested and contains 54 lakes and ponds. Together with the French River, the Quinebaug, Shetucket River Watershed and Valley, it forms the Thames River Watershed (OSRP 2011). The Thames River Watershed is the third largest watershed to drain into Long Island Sound. As indicated in the 1999 Long Island Sound Coastal Management Program Report "Population growth and associated development have had negative effects on the quality of water in the Sound." The Report notes how "Nonpoint pollution (street runoff, lawn fertilizers, etc.) is also a significant source of contamination, accounting for 21 percent of in-basin anthropogenic nitrogen loading."

Low Impact Development

Stormwater runoff can be minimized by Low Impact Development (LID) techniques. LID techniques mimic a natural process of dealing with stormwater storage, infiltration and groundwater on site. It can maintain pre-development hydrologic or can be used to retrofit a site to restore the site's hydrology. By keeping stormwater onsite, it doesn't runoff over impervious surfaces, collecting pollutants and dragging them to the various waterbodies.

Town of Sturbridge

The Town of Sturbridge's Master Plan noted the need for a Low Impact Development Bylaw to "minimize post-development stormwater runoff and further protect the town's water resources and surface and groundwater drinking supplies. The Master Plan called for the Town to "Review the design, construction, and maintenance of stormwater 'best management practices' both by the Town and private developers to ensure that the Town is taking advantage of the most recent and effective approaches to LID."

Old Sturbridge Village

Old Sturbridge Village is a New England attraction which depicts life in an early 19th-century rural Village, featuring costumed historians, antique buildings, water-powered mills, and a working farm. The current parking lot area is a mixed of paved and unpaved parking areas, and has problems with stormwater runoff. Currently, the stormwater runoff flows to a nearby pond,

which is starting to fill in with silt, thus reducing the pond's capacity to handle flow. The untreated flow is also degrading water quality entering the Quinebaug River Watershed.

To unite all the efforts and improve the quality of stormwater runoff entering into the Quinebaug River Watershed, the Town of Sturbridge partnered with Old Sturbridge Village (OSV) to allow for the increased visibility of LID techniques and the benefits of use of LID and Green Infrastructure techniques to be promoted to over a quarter million visitors annually. Project partners include the Town of Sturbridge, Old Sturbridge Village, and two subcontractors Mass Watershed Coalition and Design Consultants Inc.

Project Approach

Provide a description of the project approach including, if applicable, maps of the sampling area, sampling methodology/data acquisition, frequency, duration of sampling efforts, and data layers used for GIS mapping efforts. Provide approved QAPP in appendix.

The Central MA Regional Planning Commission's Sturbridge Stormwater Pollution Reduction Project involved:

- Task 1: Technical Assistance with the LID bylaw for the Town of Sturbridge.
- Task 2: Technical Assistance with the Stormwater Education and Outreach Program for OSV; and
- Task 3: A feasibility study, and conceptual design of stormwater improvements to the OSV main visitor parking lot.

CMRPC hired two consultants to assist with these tasks. An Environmental Planning Consultant assisted with Task 1 and 2, while an engineering consultant assisted with Task 3.

Task 1: LID Regulations

The benefit of the adoption of LID regulations is that it modifies how stormwater management practices are implemented within the Town of Sturbridge. Such adoption enables the Town to incorporate green infrastructure techniques that will guide development and redevelopment in a more sustainable manner. CMRPC and the Project Partners worked to show the community that these measures can be done in a cost-effective matter and help explore funding options for further development and maintenance.

CMRPC procured a planning consultant, Mass Watershed Coalition (MWC), to help the Town of Sturbridge successfully develop LID Regulations. CMRPC helped coordinate the formation of a "LID Working Group" that included the Town Planner, DPW Director, Conservation Agent, CMRPC staff and MWC staff. The Working Group had special review from representatives of town boards/committees including: Planning Board, Conservation Commission, Open Space Committee, and the Sturbridge Lake Advisory Committee.

Task 2: Educational Program

Task 2 involved a LID-based education component at Old Sturbridge Village (OSV). OSV, which is the largest outdoor history museum in the Northeast, depicts a rural New England town of the 1830s. They have 260,000 visitors annually, which come from across New England and beyond. Of these visitors, approximately 60,000 are school-aged children.

For this task the project team developed an educational program for Earth Day in 2016. A kick-off event at OSV was held to promote both the educational component and the LID Project as a whole. OSV historians researched 19th century stormwater management and provided a comparison to both standard greywater pipe and pond approaches and the more innovative LID/Green infrastructure techniques we wish to promote. CMRPC organized an educational booth promoting stormwater management and LID.

Task 3: Old Sturbridge Village Parking Lot Conceptual Design

For Task 3, Design Consultants Inc. worked with OSV on a conceptual drawing/feasibility for the OSV main visitor parking lot. This parking lot had been identified with having existing stormwater runoff issues. Currently the parking lot area is a mix of paved and unpaved parking areas, with unpaved areas used primarily for overflow parking during peak periods. Runoff has been carrying silt to a nearby pond, that over time is starting to fill in, which reduces its original design capacity to handle flow. The untreated flow degrades water quality entering the Quinebaug River Watershed and the LID-based stormwater management plan will provide for more direct infiltration.

CMRPC, as the lead agency for the project, administered the grant, coordinated monthly LID Working Group meetings and facilitated the development of the educational program at OSV with the Project Partners. CMRPC also completed all reporting for the project.

Results

Provide narrative description of project results including, literature/data/bylaw reviews, landuse/GIS/nutrient loading analysis, and sampling results with summary tables. Include raw data tables by sampling date in Appendix. Suggest including a discussion of Leasons Learned – what worked and what did not work during the project.

For Task 1 the Town of Sturbridge LID Working Group held four meetings, with its fourth meeting on March 1, 2017. Attendees included the town planner, conservation agent, DPW director, CMRPC staff and Mass watershed Coalition (MWC) phoned in. During the course of these meetings the working group drafted LID regulations, which were incorporated with current stormwater regulations. The final draft regulations are included as **Attachment 1** with this report. The Planning Board intends to adopt the regulations at their May 30th 2017 meeting. For Task 2, CMRPC, Sturbridge, and Old Sturbridge (OSV) held an Earth Day Program at OSV on April 22, 2016. The program included:

- Free boat rides on the Quinebaug River
- An Interactive stormwater Enviroscape activity
- Rain Garden heritage seeds planting
- Collecting the Rain with a Rain Barrel
- Sawmill and Gristmill demonstrations
- Videos about the benefits of LID
- Fact sheets on how you can help keep water clean

See Attachment 2 for photos of the educational component of this project.

In addition, the Sturbridge Planning Board and Sturbridge Conservation Commission each held a workshop to provide the public, local officials and staff an opportunity to learn about the benefits of LID and to view and comment on the draft regulations. The Planning Board was originally scheduled to vote to approve the new regulations at the end of May. However, the May meetings were delayed due to outside circumstances beyond the control of the Planning Board. In addition, the most recent meeting at the beginning of June was cancelled due to Town Meeting being extended to two nights. Currently, a hearing is scheduled to adopt the regulations July 18th.

For Task 3, CMRPC's consultant, Design Consultants Inc., completed a site visit and site assessment and drafted a report, which the project team reviewed and commented upon. The report has now been finalized and is included as **Attachment 3** with this Report.

The report assessed stormwater conditions at the Old Sturbridge Village main visitor's parking lot, developed a summary of Best Management Practices (BMPs) that will reduce nutrient and sediment loading from the parking lot to the Quinebaug River Reservoir, and developed conceptual designs with cost estimates. The goal was to identify potential alternatives for treatment of stormwater from pipes and direct surface runoff that discharges to the Quinebaug River Reservoir.

DCI recommends that improvements be made in several areas of the parking lot to reduce or eliminate pollutant sources. These improvements can be prioritized in a manner that will provide the greatest benefit relative to cost. Bioretention is a preferred BMP because in addition to reducing pollutant loads, it promotes infiltration to maintain and increase groundwater levels by adding base flow to local streams, rivers wetlands, and water supply sources. In the interim, it is recommended that Old Sturbridge Village keep up with a regular maintenance plan of cleaning existing catch basins at a minimum of two (2) times per year, sweeping the paved parking lot as needed to control sediment buildup, and plant or mulch landscape islands to minimize sediment runoff.

DCI's outlines BMP recommendations in Table 2 of their report. Following their list of BMP recommendations they then describe high priority, medium priority and low priority locations for implementation at the Site. Seventeen locations were identified for BMP placement. According to DCI, installation of BMPs at locations OS1 and OS2 will probably take care of most of the issues at the site. These two sites are described as high priority in the report.

Location 1 (OS-1) is located at the bottom of the unpaved parking lot. OS-1 is a location of high priority because it provides a direct sheet flow of surface runoff and pollutants from

approximately 3 acres of the rear parking lot directly to the River. The paved waterway and open land at the edge of the parking lot provide an ideal location for a sediment forebay with bioretention area the can be easily inspected and cleaned by Old Sturbridge Village maintenance crews as necessary. It is also recommended that the corrugated metal pipe drop inlet be replaced with a doghouse style manhole to allow an overflow outlet control structure installed in the bioretention area to be connected, while also minimizing flow of pollutants into the system. Because this area alone is not adequate to provide stormwater pretreatment for the entire 3 acre rear parking lot, it is recommended that additional stormwater pretreatment measures be implemented to support this system as outlined under Locations 3, 4, and 5, below. This is estimated to cost $23,000.

OS-2 is a location of high priority because it provides an extremely high source of pollutant contributions directly to the perennial stream and Quinebaug River Reservoir. Short of paving the 3-acre overflow parking lot to minimize erosion of the gravel to Reservoir, it is recommended that the inlet structure be removed and replaced with a manhole with cover over the existing pipe to eliminate the direct surface discharge to the pipe and a stone lined sedimentation basin with an overflow structure be constructed to capture sediment before stormwater is discharged to the pipe. This is estimated to cost $17,000.

The BMPs listed above are expected to yield the most pollutant removal for the least cost. Therefore, DCI recommends starting with these BMPs and following up with the medium and low-priority BMPs outlined in their report. Additional BMPs include more bioretention areas, sediment forebays and leaching catch basins. OSV has indicated they would like to incorporate education and outreach with the BMPs by installing educational and informational signs and teaching students about stormwater. The long term vision is to implement BMPs to manage stormwater while also educating visitors at students at OSV.

Conclusions/project summary

Present project outcomes including recommendations for further monitoring, action plans, and identification of BMPs to correct identified problems. Preliminary design plans, estimated costs, and potential sites should be provided for recommended BMPs to assist Grantee in preparing an application for 319 program.

The existing parking lot at OSV would benefit from the needed improvements and allow for its ultimate reconstruction to incorporate LID techniques. Attachment 3 in this report identifies BMPs to correct identified problems in the OSV parking lot. Preliminary design plans, estimated costs, and potential sites should are provided for recommended BMPs to assist Grantee in preparing an application for 319 program.

However, a recent development is that Old Sturbridge Village recently got approved to host a Charter School, for which temporary classrooms will be immediately placed in the parking lot area. These temporary classrooms will remain in place for a period of approximately one to two years. The temporary classrooms will be utilized permanent classrooms are erected. Due to this circumstance, the OSV is not in a position to apply for a 319 grant at this time. The BMPs cannot logically be placed until it is determined where the classrooms will be placed so as to avoid installing a BMP and then removing it a year later.

The new plan is to finalize the placement and construction of the Charter School and to then implement BMPs in coordination with a stormwater education and outreach program at the site. It may be possible to implement some BMPs during the construction of the new Charter School if the location of the classrooms means that the parking lot will be retrofitted during that process.

As mentioned above, OSV has indicated they would like to incorporate education and outreach with the BMPs by installing educational and informational signs and teaching students about stormwater. The long term vision is to implement BMPs to manage stormwater while also educating visitors at students at OSV.

The LID regulations, educational program and parking lot retrofit together will help to lead to better water quality throughout the Town, which drains into the Quinebaug River. This project can also serve as a model for other projects – weaving together components of local regulation, education and technical assistance can help further water quality improvement goals across the Commonwealth.

Literature cited

French & Quinebaug River Watersheds 2004-2008 Water Quality Assessment Report

Massachusetts 2012 Integrated List of Waters

The Town of Sturbridge's 2011 Open Space and Recreation Plan

STORMWATER MANAGEMENT REGULATIONS

- Proposed revisions added to Sections 8.01 Definitions and 8.12 Project Completion
- New section added after 8.13, titled: 8.14 Stormwater Management / Low Impact Development Performance Criteria
- Re-numerated hereafter

(Originally Adopted April 8, 2008)

8.00 PURPOSE

The purpose of these Stormwater Regulations is to protect, maintain and enhance the public health, safety, environment, and general welfare by establishing minimum requirements and procedures to control the adverse effects of increased post-development stormwater runoff, decreased groundwater recharge, and non-point source pollution associated with new development and redevelopment, as more specifically addressed in the Stormwater Bylaw of the Town of Sturbridge.

8.01 DEFINITIONS

The definitions contained herein apply to issuance of a Stormwater Management Permit (SMP) established by the Town of Sturbridge Stormwater Bylaw and implemented through these Stormwater Management Regulations. Terms not defined in this section shall be construed according to their customary and usual meaning unless the context indicates a special or technical meaning.

ALTER: Any activity, which will measurably change the ability of a ground surface area to absorb water or will change existing surface drainage patterns. Alter may be similarly represented as “alteration of drainage characteristics,” and “conducting land disturbance activities.”

APPLICANT: A property owner or agent of a property owner who has filed an application for a Stormwater Management Permit.

BEST MANAGEMENT PRACTICE (BMP): Structural, non-structural and managerial techniques that are recognized to be the most effective and practical means to prevent and/or reduce increases in stormwater volumes and flows, reduce point source and non-point source pollution, and promote stormwater quality and protection of the environment. “Structural” BMPs are devices that are engineered and constructed to provide temporary storage and treatment of stormwater runoff.

"Nonstructural" BMPs use natural measures to reduce pollution levels, do not require extensive construction efforts, and/or promote pollutant reduction by eliminating the pollutant source.

BETTER SITE DESIGN: Site design approaches and techniques that can reduce a site's impact on the watershed through the use of nonstructural stormwater management practices. Better site design includes conserving and protecting natural areas and green space, reducing impervious cover, and using natural features for stormwater management.

CERTIFICATE OF COMPLETION (COC): A document issued by the DPW Director/Town Engineer after all construction activities have been completed which states that all conditions of an issued Stormwater Management Permit have been met and that a project has been completed in compliance with the conditions set forth in a SMP.

CONVEYANCE: Any structure or device, including pipes, drains, culverts, basins, curb breaks, paved swales or man-made swales of all types designed or utilized to move or direct stormwater runoff or existing water flow.

DISTURBANCE OF LAND: Any action that causes a change in the position, location, or arrangement of soil, sand, rock, gravel or similar earth material.

DRAINAGE EASEMENT: A legal right granted by a landowner to a grantee allowing the use of private land for stormwater management purposes.

EROSION CONTROL PLAN: A plan that shows the location and construction detail(s) of the erosion and sediment reduction controls to be utilized for a construction site.

HOTSPOT: Land uses or activities with higher potential pollutant loadings, such as auto salvage yards, auto fueling facilities, fleet storage yards, commercial parking lots with high intensity use, road salt storage areas, commercial nurseries and landscaping, outdoor storage and loading areas of hazardous substances.

IMPERVIOUS SURFACE: Any material or structure on or above the ground that prevents water from infiltrating through the underlying soil. Impervious surface is defined to include, without limitation: paved parking lots, sidewalks, roof tops, driveways, patios, and paved, gravel and compacted dirt surfaced roads.

MASSACHUSETTS STORMWATER MANAGEMENT POLICY: The Policy issued by the Department of Environmental Protection, and as amended, that coordinates the requirements prescribed by state regulations promulgated under the authority of the Massachusetts Wetlands Protection Act MGL Ch. 131 § 40 and Massachusetts Clean Waters Act MGL Ch. 21, § 23-56. The Policy addresses stormwater impacts through implementation of performance standards to reduce or prevent pollutants from reaching water bodies and control the quantity of runoff from a site.

MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4) or MUNICIPAL STORM DRAIN SYSTEM: The system of conveyances designed or used for collecting or conveying stormwater, including any road with a drainage system, street, gutter, curb, inlet, piped storm drain, pumping facility, retention or detention basin, natural or man-made or altered drainage channel, reservoir, and other drainage structure that together comprise the storm drainage system owned or operated by the Town of Sturbridge.

NEW DEVELOPMENT: Any construction activities or land alteration resulting in total earth disturbances equal to or greater than 1 acre (or activities that are part of a larger common plan of development disturbing greater than 1 acre) on an area that has not previously been developed to include impervious cover.

NONPOINT SOURCE POLLUTION: Pollution from many diffuse sources caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into water resource areas.

OPERATION AND MAINTENANCE PLAN: A plan that defines the functional, financial and organizational mechanisms for the ongoing operation and maintenance of a stormwater management system to insure that it continues to function as designed.

OWNER: A person with a legal or equitable interest in a property.

PERSON: Any individual, group of individuals, association, partnership, corporation, company, business organization, trust, estate, the Commonwealth or political subdivision thereof to the extent subject to Town Bylaws, administrative agency, public or quasi-public corporation or body, the Town of Sturbridge, and any other legal entity, its legal representatives, agents, or assigns.

PRE-DEVELOPMENT: The conditions that exist at the time that plans for the land development of a tract of land are submitted to the DPW Director/Town Engineer. Where phased development or plan approval occurs (preliminary grading, roads and utilities, etc.), the existing conditions at the time prior to the first plan submission shall establish pre-development conditions.

POINT SOURCE: Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, or container from which pollutants are or may be discharged.

POST-DEVELOPMENT: The conditions that reasonably may be expected or anticipated to exist after completion of the land development activity on a specific site or tract of land. Post-development refers to the phase of a new development or redevelopment project after completion, and does not refer to the construction phase of a project.

RECHARGE: The replenishment of underground water reserves.

REDEVELOPMENT: Any construction, land alteration, or improvement of impervious surfaces resulting in total earth disturbances equal to or greater than 1 acre (or activities that are part of a larger common plan of development disturbing greater than 1 acre) that does not meet the definition of new development.

RESOURCE AREA: Any area protected under including without limitation: the Massachusetts Wetlands Protection Act, Massachusetts Rivers Act, or Town of Sturbridge Wetlands Protection Bylaw.

SITE: The area extent of construction activities, including but not limited to the creation of new impervious cover and improvement of existing impervious cover.

STORMWATER AUTHORITY: The Board of Selectman or duly authorized representatives that has the authority to administer, implement, and enforce these Stormwater Regulations. The DPW Director/Town Engineer is responsible for coordinating the review, approval and permit process as defined in this Bylaw. Other Boards and/or departments participate in the review process as defined in Section 4 of these Stormwater Regulations.

STORMWATER MANAGEMENT: The use of structural or non-structural practices that are designed to reduce storm water runoff pollutant loads, discharge volumes, and/or peak flow discharge rates.

STORMWATER MANAGEMENT PERMIT (SMP): A permit issued by the DPW Director/Town Engineer after review of an application, plans, calculations, and other supporting documents, which is designed to protect the environment of the Town from the deleterious affects of uncontrolled and untreated stormwater runoff.

STOP WORK ORDER: An order issued which requires that all construction activity on a site be stopped.

TSS: Total Suspended Solids.

WATER QUALITY VOLUME (WQv): The storage needed to capture a specified average annual stormwater runoff volume. Numerically (WQv) will vary as a function of drainage area or impervious area.

8.03 Authority

A. The Rules and Regulations contained herein have been adopted by the DPW Director/Town Engineer, Planning Board and Conservation Commission in accordance with the Town of Sturbridge Stormwater Bylaw.

B. Nothing in these Rules and Regulations is intended to replace or be in derogation of the requirements of the Town of Sturbridge Wetlands Protection Bylaw or any Rules and Regulations adopted thereunder.

C. These Stormwater Regulations may be periodically amended by the DPW Director/Town Engineer in accordance with the procedures outlined in the Town of Sturbridge Stormwater Bylaw.

8.04 Administration

A. The DPW Director/Town Engineer shall administer, implement and enforce these Regulations under the direction of the Board of Selectman. Town Boards, including, but not limited to the Conservation Commission, Planning Board, Zoning Board of Appeals, Department of Public Works, Building Department, Board of Health and others who issue permits and/or approvals for projects and/or activities under their specific jurisdiction shall review projects in accordance with these Regulations as adopted and amended from time to time by the Board of Selectman. Projects or activities approved by the Planning Board and/or Conservation Commission shall be deemed in compliance with the intent and provisions of these Stormwater Regulations. Each Board must forward written documentation of said approval and all conditions of approval to the DPW Director/Town Engineer within 20 business days of said approval (or the agreed to extended time). Upon receipt of written approval from the Board(s), the DPW Director/Town Engineer shall issue a Stormwater Management Permit to the applicant within 30 business days.

   Note: The above provision is designed to allow existing Town Boards, Commissions and/or Departments who have current jurisdiction over project approval activities to continue their current review procedures, but to add a provision that would authorize these entities to review and approve stormwater management facilities designed in accordance with this regulation.

8.05 Applicability

A. These Stormwater Regulations apply to all activities in accordance with the applicability section of the Town of Sturbridge Stormwater Bylaw and further described in this section. Projects and/or activities not specifically under the currently regulated jurisdiction of any of the Town of Sturbridge boards, commissions or departments but still within the jurisdiction of the Town of Sturbridge Stormwater Bylaw must obtain a Stormwater Management Permit from the DPW Director/Town Engineer in accordance with the permit procedures and requirements defined in Section 8.06 of these Regulations. For projects and/or activities within the currently regulated jurisdiction of any of the Town of Sturbridge boards, commission or departments, the specific application submission requirements, public notices, and fee requirements of the

applicable board, commission and/or department shall govern. Not withstanding these requirements, the Stormwater Management Plan Contents, Operation and Maintenance Plan Contents, and Stormwater Review Fee, under Section 8.06 of these Regulations must also be met.

1. Exemptions
   No person shall alter land within the Town of *Sturbridge* without having obtained a Stormwater Management Permit (SMP) for the property with the following exceptions:

   a. Normal maintenance and improvement of land in agricultural use as defined by the Wetlands Protection Act regulation 310 CMR 10.04 and MGL Chapter 40A Section 3.
   b. Maintenance of existing landscaping, gardens or lawn areas associated with a single family dwelling where no greater than 100 cubic yards of land disturbance is involved;
   c. Repair or replacement of an existing roof of a single-family dwelling;
   d. The construction of any fence that will not alter existing terrain or drainage patterns;
   e. Construction of utilities (gas, water, electric, telephone, etc.) other than drainage, which will not alter terrain, ground cover, or drainage patterns;
   f. Emergency repairs to any stormwater management facility or practice that poses a threat to public health or safety, or as deemed necessary by the *Department of Public Works/Town Engineer;*
   g. Any work or projects for which all necessary approvals and permits have been issued before the effective date of this Bylaw;

8.06 Permit Procedures and Requirements

A. Projects requiring a stormwater management permit shall be required to submit the materials as specified in this section, and are required at a minimum to meet stormwater management guidelines of all federal, state and/or local regulations.

B. Permit Required

   1. No land owner or land operator shall receive any of the building, grading or other land development permits required for land disturbance activities without first meeting the requirements of this Bylaw prior to commencing the proposed activity.

   2. Should a land-disturbing activity associated with an approved plan in accordance with this section not begin during the 180-day period following permit issuance, the DPW Director/Town Engineer may evaluate the existing stormwater

management plan to determine whether the plan still satisfies local program requirements and to verify that all design factors are still valid. If the authority finds the previously filed plan to be inadequate, a modified plan shall be submitted and approved prior to the commencement of land-disturbing activities.

C. Filing Application

1. The applicant shall file with the DPW Director/Town Engineer, three (3) copies of a completed application package for a Stormwater Management Permit (SMP). Permit issuance is required prior to any site altering activity. While the applicant can be a representative, the permittee must be the owner of the site. The SMP Application package shall include:

    a. A completed Stormwater Management Permit Application Form with original signatures of all owners.
    b. Stormwater Management Plan and project description.
    c. Operation and Maintenance Plan.
    d. Payment of the application and review fees.
    e. Inspection and Maintenance agreement.
    f. Erosion and Sediment Control Plan.
    g. Surety bond.

8.07 Entry

Filing an application for a permit grants the duly authorized agent permission to enter the site to verify the information in the application and to inspect for compliance with the resulting permit.

8.08 Fees

The Stormwater Authority shall obtain with each submission an Application Fee established by the DPW Director/Town Engineer to cover expenses connected with the review of the Stormwater Management Permit and a technical review fee sufficient to cover professional review services or the project. The DPW Director/Town Engineer is authorized to retain a Registered Professional Engineer or other professional consultant to advise the DPW Director/Town Engineer on any or all aspects of these plans. Applicants must pay review fees before the review process may begin.

1. Rules

    a. Application fees are payable at the time of application and are non-refundable.

b. Application fees shall be calculated by the DPW Director/Town Engineer in accordance with the fee schedule below.
c. These fees are in addition to any other local or state fees that may be charged under any other law, Bylaw, or local ordinance.
d. The fee schedule may be reduced or increased by the DPW Director/Town Engineer. Any such change shall be made at a posted public hearing of the Board of Selectman not less than [30] days prior to the date upon which the change is to be effective.

2. Stormwater Management Plan Review Fee Schedule: Appendix A

3. Engineering and Consultant Reviews and Fees

a. The DPW Director/Town Engineer is authorized to require an applicant to pay a fee for the reasonable costs and expenses for specific expert engineering and other consultant services deemed necessary by the DPW Director/Town Engineer to come to a final decision on the application. This fee is called the "Engineering and Consultant Review Fee."

b. Payment may be required at any point in the deliberations prior to a final decision.
c. Any application filed with the DPW Director/Town Engineer must be accompanied by a completed Engineering Consultant Fee Acknowledgement form.

d. Consultant fees shall be determined at the time of project review based on a specific scope of work, and shall be calculated at a rate of as the Stormwater Authority may determine.

e. The services for which a fee may be utilized include, but are not limited to, wetland survey and delineation, hydrologic and drainage analysis, wildlife evaluation, stormwater quality analysis, site inspections, as-built plan review, and analysis of legal issues.

f. The DPW Director/Town Engineer is authorized to require an applicant to pay reasonable costs and expenses for certain activities, which utilize the services of Town Staff. This includes such activities as inquiries concerning potential projects as well as site inspections not associated with a pending permit application.

g. The DPW Director/Town Engineer may require any applicant to pay an additional fee of $30.00 per hour for review, inspection and monitoring services for any project filing that requires an excess of two (2) hours of review, inspection, and monitoring time by a Town Staff member.

h. Subject to applicable law, any unused portion of any fees collected shall be returned by the DPW Director/Town Engineer to the applicant within sixty calendar days of a written request by the applicant, unless the DPW Director/Town Engineer decides in a public meeting that other action is necessary.

i. The Engineering and Consultant Review fees collected under this section shall be deposited in a revolving account. The DPW Director/Town Engineer shall include a full accounting of the revolving account as part of its annual report to the Town.

8.09 ACTIONS

The DPW Director/Town Engineer's action, rendered in writing, shall consist of either:

1. Approval of the Stormwater Management Permit Application based upon determination that the proposed plan meets the Standards in Section 8.06 and will adequately protect the water resources of the community and is in compliance with the requirements set forth in this Bylaw.
2. Approval of the Stormwater Management Permit Application subject to any conditions, modifications or restrictions required by the DPW Director/Town Engineer which will ensure that the project meets the Standards in Section 8.06 and adequately protects water resources, set forth in this Bylaw.
3. Disapproval of the Stormwater Management Permit Application based upon a determination that the proposed plan, as submitted, does not meet the Standards in Section 6 or adequately protects water resources, as set forth in this Bylaw.
4. The DPW Director/Town Engineer may disapprove an application "without prejudice" where an applicant fails to provide requested additional information that in the DPW Director/Town Engineer's opinion is needed to adequately describe the proposed project. Information shall generally be limited to those items listed in Section 8.06 of these Regulations.

For projects not requiring permits from other town boards including but not limited to Conservation Commission, Planning Board, Zoning Board of Appeals etc., failure of the DPW Director/Town Engineer to take final action upon an Application within 65 calendar days of receipt of a complete application shall be deemed to be approval of said Application. Upon certification by the Town Clerk that the allowed time has passed without DPW Director/Town Engineer action, the DPW Director/Town Engineer must issue a Stormwater Management Permit.

8.10 Plan Changes

The permittee must notify the DPW Director/Town Engineer in writing of any drainage change or alteration in the system authorized in a Stormwater Management Permit

before any change or alteration is made. If the DPW Director/Town Engineer determines that the change or alteration is significant, based on the Stormwater Management Standards in Section 8.06 and accepted construction practices, the DPW Director/Town Engineer may require that an amended application be filed.

8.11 Appeals of Actions of the DPW Director/Town Engineer

A decision of the DPW Director/Town Engineer shall be final. Further relief of a decision by the DPW Director/Town Engineer made under these Regulations shall be reviewable in the Superior Court in an action filed within 20 calendar days thereof, in accordance with MGL Ch. 249. § 4. An appeal of an action by a board, commission or department that has current regulatory authority for a project and/or activity shall be conducted under the applicable appeal provisions of said board, commission and/or department of the Town of Sturbridge. Such an appeal shall result in revocation of the written approval as described under Section 8.04 of these Regulations, until such time as the appeal process of the applicable board, commission and/or department has been resolved.

8.12 Project Completion

At completion of the project the permittee shall submit as-built record drawings of all structural stormwater controls and treatment best management practices required for the site as required in Section 8.06. The as-built drawings must depict all on site controls, both structural and non-structural, designed to manage the stormwater associated with the completed site (post construction stormwater management). The as-built drawing shall show deviations from the approved plans, if any, and be certified by a Registered Professional Engineer.

8.13 Stormwater Management Plan Contents

1. The application for a stormwater management permit shall include the submittal of a Stormwater Management Plan to the DPW Director/Town Engineer. This Stormwater Management Plan shall contain sufficient information for the DPW Director/Town Engineer to evaluate the environmental impact, effectiveness, and acceptability of the measures proposed by the applicant for reducing adverse impacts from stormwater runoff. This plan shall be in accordance with the criteria established in these regulations and must be submitted with the stamp and signature of a Professional Engineer (PE) licensed in the Commonwealth of Massachusetts.
2. The Stormwater Management Plan shall fully describe the project in drawings, narrative, and calculations. It shall include:

    a. Contact Information. The name, address, and telephone number of all persons having a legal interest in the property and the tax reference number and parcel number of the property or properties affected.

b. A locus map (preferably copy of Assessor's Map).
c. The existing zoning, and land use at the site.
d. The proposed land use.
e. The location(s) of all existing and proposed easements.
f. The location of existing and proposed utilities.
g. The site's existing and proposed topography with contours at 2 foot intervals.
h. The existing site hydrology.
i. A description & delineation of existing stormwater conveyances, impoundments, and wetlands (subject to protection under the state and local wetland regulations) on or adjacent to the site or into which stormwater flows.
j. A delineation of 100-year flood plains, if applicable.
k. Field verified seasonal high groundwater elevation in areas to be used for stormwater retention, detention, or infiltration (information to be shown on a plan and verified by a professional).
l. The existing and proposed vegetation and ground surfaces with runoff coefficients for each.
m. A drainage area map showing pre and post construction watershed boundaries, drainage area and stormwater flow paths, including municipal drainage system flows.
n. A description and drawings of all components of the proposed stormwater management system including:
    1. Locations, cross sections, and profiles of all brooks, streams, drainage swales and their method of stabilization.
    2. All measures for the detention, retention or infiltration of water.
    3. All measures for the protection of water quality.
    4. The structural details for all components of the proposed drainage systems and stormwater management facilities.
    5. Notes on drawings specifying materials to be used, construction specifications, and expected hydrology with supporting calculations.
    6. Proposed improvements including location of buildings or other structures, impervious surfaces, and drainage facilities, if applicable.
    7. Any other information requested by the DPW Director/Town Engineer
o. Hydrologic and hydraulic design calculations for the pre-development and post-development conditions for the design storms specified in this Regulation. Such calculations shall include:

    1. Description of the design storm frequency, intensity and duration.
    2. Time of concentration
    3. Soil Runoff Curve Number (RCN) based on land use and soil hydrologic group.
    4. Peak runoff rates and total runoff volumes for each watershed area.
    5. Information on construction measures used to maintain the infiltration capacity of the soil where any kind of infiltration is proposed.
    6. Infiltration rates, where applicable.
    7. Culvert capacities.

8. Flow velocities.
9. Data on the increase in rate and volume of runoff for the specified design storms.
10. Documentation of sources for all computation methods and field test results.

p. Post-Development analysis is required to document that post-development flow conditions do not exceed pre-development flow conditions
q. Soils Information from test pits performed at the location of proposed stormwater management facilities, including but not limited to soil descriptions, depth to seasonal high groundwater, depth to bedrock, and percolation rates. Soils information will be based on site test pits logged by a Massachusetts Registered Soil Evaluator, or a Massachusetts Registered Professional Engineer.
r. Landscaping plan describing the woody and herbaceous vegetative stabilization and management techniques to be used within and adjacent to the stormwater practice.

K. Operation and Maintenance Plan Contents

An Operation and Maintenance plan (O&M Plan) is required at the time of application for all projects. The maintenance plan shall be designed to ensure compliance with the Permit, this Bylaw and that the Massachusetts Surface Water Quality Standards, 314, CMR 4.00 are met in all seasons and throughout the life of the system. The Operation and Maintenance Plan shall remain on file with the DPW Director/Town Engineer and shall be an ongoing requirement. Additionally, the O&M Plan shall be recorded at the Worcester County Registry of Deeds. Proof of recording shall be submitted to the DPW Director/Town Engineer (condition of the Stormwater Permit). The O&M Plan shall include at a minimum:

1. The name(s) of the owner(s) for all components of the system.
2. A map showing the location of the systems and facilities including catch basins, manholes/access lids, main, and stormwater devices.
3. Maintenance agreements that specify:
    a. The names and addresses of the person(s) responsible for operation and maintenance.
    b. The person(s) responsible for financing maintenance and emergency repairs.
    c. An Inspection and Maintenance Schedule for all stormwater management facilities including routine and non-routine maintenance tasks to be performed.
    d. A list of easements with the purpose and location of each.
    e. The signature(s) of the owner(s).

4. Stormwater Management Easement(s)

a. Stormwater management easements shall be provided by the property owner(s) as necessary for:
    1. Access for facility inspections and maintenance.
    2. Preservation of stormwater runoff conveyance, infiltration, and detention areas and facilities, including flood routes for the 100-year storm event.
    3. Direct maintenance access by heavy equipment to structures requiring regular maintenance.

b. The purpose of each easement shall be specified in the maintenance agreement signed by the property owner.

c. Stormwater management easements are required for all areas used for off-site stormwater control, unless a waiver is granted by the DPW Director/Town Engineer

d. Easements shall be recorded with the Worcester County Registry of Deeds prior to issuance of a Certificate of Completion by the DPW Director/Town Engineer.

5. Changes to Operation and Maintenance Plans
    a. The owner(s) of the stormwater management system must notify the DPW Director/Town Engineer of changes in ownership or assignment of financial responsibility, and must transfer Operation and Maintenance Plan responsibilities to subsequent owners.

    b. The maintenance schedule in the Maintenance Agreement may be amended to achieve the purposes of this Regulation by mutual agreement of the DPW Director/Town Engineer and the Responsible Parties. Amendments must be in writing and signed by all Responsible Parties. Responsible Parties shall include owner(s), persons with financial responsibility, and persons with operational responsibility.

8.14 STORM WATER MANAGEMENT / LOW IMPACT DEVELOPMENT PERFORMANCE CRITERIA

A. Exemptions

In addition to the exemptions listed in Section 8.05 APPLICABILITY, the following exemptions apply:

1. Single family homes
2. Maintenance of existing paved surfaces
3. Resurfacing of existing paved surfaces
4. Project sites creating a disturbance of land of less than one acre in size

Exempted projects are still strongly encouraged to use Low Impact Development (LID) site planning and design strategies for new development and redevelopment projects.

B. Site Planning Process

Low Impact Development (LID) site planning and design strategies must be used to the maximum extent feasible, and the design of treatment and infiltration practices should follow the guidance in Volume 2 of the Massachusetts Stormwater Handbook (See the DEP Stormwater Handbook Volume 2 Ch 1, for a discussion of non-structural approaches to stormwater management).

The site planning process shall be documented and shall include the following steps:

1. identify and map critical environmental resources,
2. delineate potential building envelopes avoiding environmental resource areas and appropriate buffers,
3. develop methods to minimize impervious surfaces, and to protect and preserve open space.

C. Stormwater Credits

The use of Better Site Design and nonstructural stormwater management measures is encouraged to minimize reliance on structural stormwater management measures. The use of one or more site design measures by the applicant may allow for a reduction in the water quality treatment volume required and the stream channel protection volume required. The applicant may, if approved by the Stormwater Authority, take credit for the use of stormwater better site design practices to reduce some of the requirements specified in the criteria section of these regulations. The site design practices that qualify for these credits and procedures for applying and calculating the credits are identified in Appendix A, which follows at the end of these regulations.

D. Stormwater Management in New Development and Redevelopment (Post Construction Stormwater Management)

Objective: The objective of this control measure is to reduce the discharge of pollutants found in stormwater through the retention or treatment of stormwater after construction on new or redeveloped sites. This regulation is designed to address post-construction stormwater runoff from all new development and redevelopment sites that disturb one or more acres. This includes sites less than one

acre if the site is part of a larger common plan of development or redevelopment which disturbs one or more acre.

1. Stormwater management systems on new development sites shall be designed to:
    a. Not allow new stormwater conveyances to discharge untreated stormwater in accordance with Massachusetts Stormwater Handbook Standard 1;
    b. Control peak runoff rates in accordance with Massachusetts Stormwater Handbook Standard 2;
    c. Recharge groundwater in accordance with Massachusetts Stormwater Handbook Standard 3;
    d. Eliminate or reduce the discharge of pollutants from land uses with higher pollutant loads as defined in the Massachusetts Stormwater Handbook in accordance with Massachusetts Stormwater Handbook Standard 5,
    e. Protect Zone II or Interim Wellhead Protection Areas of public water supplies in accordance with Massachusetts Stormwater Handbook Standard 6;
    f. Implement long term maintenance practices in accordance with Massachusetts Stormwater Handbook Standard 9; and
    g. Require that all stormwater management systems be designed to:
        i. Retain the volume of runoff equivalent to, or greater than, one (1.0) inch multiplied by the total post-construction impervious surface area on the site AND/OR
        ii. Remove 80% of the average annual load of Total Suspended Solids (TSS) generated from the total post-construction impervious area on the site14 AND 60% of the average annual load of Total Phosphorus (TP) generated from the total post-construction impervious surface area on the site. Pollutant removal shall be calculated consistent with EPA Region 1's BMP Performance Extrapolation Tool or other BMP performance evaluation tool provided by EPA Region 1, where available. If EPA Region 1 tools do not address the planned or installed BMP performance any federally or State approved BMP design guidance or performance standards (e.g. State stormwater handbooks and design guidance manuals) may be used to calculate BMP performance.

2. Redevelopment Requirements
    a. Stormwater management systems on Redevelopment sites shall meet the following Massachusetts Stormwater Standards to the maximum extent feasible:
        i. Massachusetts Stormwater Standard 1;
        ii. Massachusetts Stormwater Standard 2;
        iii. Massachusetts Stormwater Standard 3; and
        iv. The pretreatment and structural best management practices requirements of Massachusetts Stormwater Standards 5 and 6.
    b. Stormwater management systems on Redevelopment sites shall also improve existing conditions by requiring that stormwater management systems be designed to:
        i. Retain the volume of runoff equivalent to, or greater than, 0.80 inch multiplied by the total post-construction impervious surface area on the site AND/OR Remove 80% of the average annual post-construction load of Total Suspended Solids (TSS) generated from the total post-construction impervious area on the site AND 50% of the average annual load of Total Phosphorus (TP) generated from the total post construction impervious surface area on the site.
        ii. Pollutant removal shall be calculated consistent with EPA Region 1's BMP Performance Extrapolation Tool or other BMP performance evaluation tool provided by EPA Region 1 where available. If EPA Region 1 tools do not address the planned or installed BMP performance any federally or State approved BMP design guidance or performance standards (e.g. Massachusetts Stormwater handbooks and design guidance manuals) may be used to calculate BMP performance.
        iii. Stormwater management systems on redevelopment sites may utilize offsite mitigation within the same USGS HUC10 as the redevelopment site to meet the equivalent retention or pollutant removal requirements.
    c. Redevelopment activities that are exclusively limited to maintenance and improvement of existing roadways, (including widening less than a single lane, adding shoulders, correcting substandard intersections, improving existing drainage systems, and repaving projects) shall improve existing conditions where feasible and are exempt. Roadway widening or improvements that increase the amount of impervious area on the

redevelopment site by greater than or equal to a single lane width shall meet the redevelopment requirements fully.

8.15 WAIVERS

A. The DPW Director/Town Engineer may waive strict compliance with any requirement of the Town of Sturbridge Stormwater Bylaw or the rules and regulations promulgated hereunder, where:
   a. such action is allowed by federal, state and local statutes and/or regulations.
   b. such action is in the public interest.
   c. such action is not inconsistent with the purpose and intent of the Town of Sturbridge Stormwater Bylaw.

B. Any applicant may submit a written request to be granted such a waiver. Such a request shall be accompanied by an explanation or documentation supporting the waiver request and demonstrating that strict application of the Bylaw does not further the purposes or objectives of this bylaw.

C. All waiver requests shall be acted on within 45 calendar days and written finding will be provided by the DPW Director/Town Engineer

D. If in the DPW Director/Town Engineer's opinion, additional time or information is required for review of a waiver request, the DPW Director/Town Engineer may request an extension of the review period. In the event the applicant objects to an extension, or fails to provide requested information, the waiver request may be denied, "without prejudice" by the DPW Director/Town Engineer.

8.16 SURETY

The DPW Director/Town Engineer may require the permittee to post before the start of land disturbance or construction activity, a surety bond, irrevocable letter of credit, cash, or other acceptable security. The form of the bond shall be approved by town counsel, and be in an amount deemed sufficient by the DPW Director/Town Engineer to ensure that the work will be completed in accordance with the permit. If the project is phased, the DPW Director/Town Engineer may release part of the bond as each phase is completed in compliance with the permit but the bond may not be fully released until the DPW Director/Town Engineer has received the final inspection report as required by Section 9 of these Regulations and issued a Certificate of Completion.

8.17 CONSTRUCTION INSPECTIONS

A. Notice of Construction Commencement. The applicant must notify the DPW Director/Town Engineer in advance before the commencement of construction. In

addition, the applicant must notify the DPW Director/Town Engineer in advance of construction of critical components of the stormwater facility.

At the discretion of the DPW Director/Town Engineer periodic inspections of the stormwater management system construction shall be conducted by the DPW Director or a professional engineer or their designee who has been approved by the DPW Director/Town Engineer.

B. Final Inspection. After the stormwater management system has been constructed and before the surety has been released, all applicants are required to submit actual “as built” plans for any stormwater management facilities or practices after final construction is completed and must be certified by a Professional Engineer.

The DPW Director/Town Engineer shall inspect the system to confirm its "as-built" features. This inspector shall also evaluate the effectiveness of the system in an actual storm. If the inspector finds the system to be adequate he shall so report to the DPW Director/Town Engineer which will issue a Certificate of Completion. As built plans shall be full size plans which reflect the “as built” conditions, including all final grades, developed by a Professional Engineer. All changes to project design should be recorded in red ink on plans to define changes made. All work deleted, corrections in elevations, and changes in materials, should be shown on the as built drawings.

C. Inadequacy of System

1. If the system is found to be inadequate by virtue of physical evidence of operational failure, even though it was built as called for in the Stormwater Management Plan, it shall be corrected by the applicant before the Certificate of Completion is released. If the applicant fails to act the DPW Director/Town Engineer may use the surety bond to complete the work.

2. If the DPW Director/Town Engineer determines that there is a failure to comply with the plan, the property owner shall be notified in writing of the nature of the violation and the required corrective actions. A Stop Work Order shall be issued until any violations are corrected and all work previously completed has received approval by the DPW Director/Town Engineer

8.18 CERTIFICATE OF COMPLETION

A. Upon completion, the applicant is responsible for certifying (by a professional Engineer) that the completed project is in accordance with the approved plans and specifications and shall provide regular inspections sufficient to adequately document compliance.

B. The DPW Director/Town Engineer will issue a Certification of Completion in the form of a letter indicating the following:

1. the conditions of the permit have been met
2. the final inspection and reports have been accepted
3. a determination that all work specified by the permit has been satisfactorily completed in conformance with the Town of Sturbridge Stormwater Management Regulations.

8.19 PERPETUAL INSPECTION AND MAINTENANCE

A. Maintenance Responsibility

1. Stormwater management facilities and practices included in a stormwater management plan with an inspection and maintenance agreement in accordance with Section 8.06 of these Regulations must undergo ongoing inspections to document maintenance and repair needs and ensure compliance with the requirements of the agreement, the plan and this Regulation.

2. The owner of the property on which work has been done pursuant to this Regulation for private stormwater management facilities, or any other person or agent in control of such property, shall maintain in good condition and promptly repair and restore all grade surfaces, walls, drains, dams and structures, vegetation, erosion and sedimentation controls, and other protective devices. Such repairs or restoration and maintenance shall be in accordance with approved plans.

3. All stormwater management facilities must undergo inspections to document maintenance and repair needs and ensure compliance with the requirements of this bylaw and accomplishment of its purposes as specified in the Operation and Maintenance Plan and Maintenance Agreement described under Section 6 of these regulations.

4. At a minimum, inspections shall occur during the first year of operation and at least once every three years thereafter. In addition, a maintenance agreement as specified under Section 6 of these regulations between the owner and the DPW Director/Town Engineer shall be executed for privately-owned stormwater management systems that specifies the Responsible Party for conducting long term inspections.

5. Inspection reports shall be submitted to and maintained by the DPW Director/Town Engineer for all stormwater management systems. The DPW

Director/Town Engineer reserves the right to require specific information in the inspection reports.

C. Right-of-Entry for Inspection

The terms of the inspection and maintenance agreement as specified in Section 6 of these regulations shall provide for the DPW Director/Town Engineer or its designee to enter the property at reasonable times and in a reasonable manner for the purpose of inspection. The DPW Director/Town Engineer, its agents, officers, and employees shall have authority to enter upon privately owned land for the purpose of performing their duties under this Regulation and may make or cause to be made such examinations, surveys, or sampling as the DPW Director/Town Engineer deems necessary, subject to the constitutions and laws of the United States and the Commonwealth.

8.20 ENFORCEMENT

A. The DPW Director/Town Engineer or an authorized agent of the DPW Director/Town Engineer shall enforce this Bylaw, regulations, orders, violation notices, and enforcement orders, and may pursue all civil, criminal and non-criminal remedies for such violations.

B. Notices and Orders

1. The DPW Director/Town Engineer or an authorized agent of the DPW Director/Town Engineer may issue a written notice of violation or enforcement order to enforce the provisions of this Bylaw or the regulations thereunder, which may include requirements to:

    a. Cease and desist from construction or land disturbing activity until there is compliance with the Bylaw and the stormwater management permit.

    b. Repair, maintain; or replace the stormwater management system or portions thereof in accordance with the operation and maintenance plan.

    c. Perform monitoring, analyses, and reporting.

    d. Fix adverse impact resulting directly or indirectly from malfunction of the stormwater management system.

2. If the enforcing person determines that abatement or remediation of adverse impacts is required, the order may set forth a deadline by which such abatement or remediation must be completed. Said order may further

advise that, should the violator or property owner fail to abate or perform remediation within the specified deadline, the Town of Sturbridge may, at its option, undertake such work, and the property owner shall reimburse the Town of Sturbridge for expenses incurred.

3. Within thirty (30) days after completing all measures necessary to abate the violation or to perform remediation, the violator and the property owner shall be notified of the costs incurred by the Town of Sturbridge including administrative costs. The violator or property owner may file a written protest objecting to the amount or basis of costs with the DPW Director/Town Engineer within thirty (30) days of receipt of the notification of the costs incurred. If the amount due is not received by the expiration of the time in which to file a protest or within thirty (30) days following a decision of the DPW Director/Town Engineer affirming or reducing the costs, or from a final decision of a court of competent jurisdiction, the costs shall become a special assessment against the property owner and shall constitute a lien on the owner's property for the amount of said costs. Interest shall begin to accrue on any unpaid costs at the statutory rate provided in MGL Ch. 59, § 57, after the thirty-first day at which the costs first become due.

4. Any person who violates any provision of the Town of Sturbridge Stormwater Bylaw, or regulation, order or permit issued thereunder, may be ordered to correct the violation and/or shall be punished by a fine of not more than $50.00. Each day or part thereof that such violation occurs or continues shall constitute a separate offense.

5. Non-Criminal Disposition. As an alternative to criminal prosecution or civil action, the Town of Sturbridge may elect to utilize the non-criminal disposition procedure set forth in MGL Ch. 40, §21D and Chapter 9 of the General Bylaws of the Town of Sturbridge in which case DPW Director/Town Engineer of the Town of Sturbridge shall be the enforcing agent. The penalty for the 1st violation shall be $50.00. The penalty for the 2nd violation and subsequent violations shall be $100.00. Each day or part thereof that such violation occurs or continues shall constitute a separate offense.

6. Appeals. The decisions or orders of the DPW Director/Town Engineer shall be final. Further relief shall be to a court of competent jurisdiction.

7. Remedies Not Exclusive. The remedies listed in this Bylaw are not exclusive of any other remedies available under any applicable federal, state or local law.

8.21 SEVERABILITY

The invalidity of any section, provision, paragraph, sentence, or clause of these Regulations shall not invalidate any section, provision, paragraph, sentence, or clause thereof, nor shall it invalidate any permit or determination that previously has been issued.

Pictures from Earth Day Event at Old Sturbridge Village

Earth Day April 20, 2016

Youth participate in the EnviroScape activity.

The Sturbridge 604b Stormwater Education table was crowded the entire day.

Learning about pervious pavement.

Making it rain using spray bottles.

Pervious concrete educational display.

Filling up the lake with clean water before the activity begins.

Youth dressed up for the Old Sturbridge Village theme participate in the EnviroScape activity.

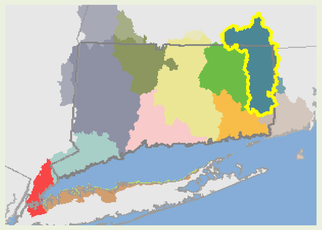
Youth dressed up for the Old Sturbridge Village theme participate in the EnviroScape activity.

Adding “contaminants” to the EnviroScape Model.

Low Impact Development
Reducing Stormwater Pollution in the Quinebaug River Watershed

Overview

The Central Massachusetts Regional Planning Commission (CMRPC) , the Town of Sturbridge, and Old Sturbridge Village have partnered to improve water quality in the Quinebaug River Watershed.



The Quinebaug watershed is 704 square miles and covers the northeastern corner of Connecticut and parts of Massachusetts and Rhode Island.

The project team will implement three phases:

- **Community Awareness**
  Hold a workshop to introduce Low Impact Development at the Sturbridge Town Offices in Spring 2016.

- **Low Impact Development Bylaw**
  Help develop a LID bylaw that is tailored to meet the Town's needs.

- **Old Sturbridge Village Parking Improvement**
  Identify measures to improve stormwater management in the OSV's parking lot.

The parking lot at Old Sturbridge Village experiences erosion and sediment issues during rain events.

What is stormwater?

Stormwater runoff is the Nation's number one source of water pollution. Stormwater runoff is water from rain or melting snow that "runs off" across the land instead of seeping into the ground.

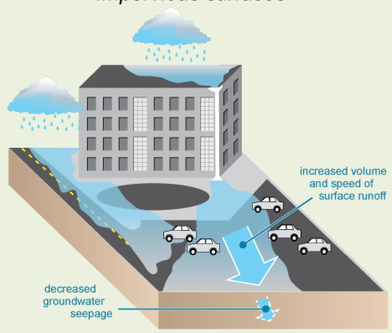
Why is stormwater a problem?

When hardened surfaces such as roads, parking lots, and rooftops are constructed, the movement of water is altered. In particular, stormwater runoff carries dirt, debris, oil, metals and other pollutants from streets and paved areas into streams and lakes. Rapid runoff also limits the infiltration of rain and snow melt, which reduces the groundwater recharge that keeps brooks and ponds healthy.

How Low Impact Development can help

LID is an alternative land development practice that helps to preserve the environmental quality of the site or region. LID designs with nature in mind: working with the existing landscape and hydrology to minimize adverse impacts. LID methods keep rain and snow-melt on the site where it falls, rather than using pipes to discharge polluted stormwater into local waterways. LID methods benefit industrial, residential and commercial development and redevelopment, and have proven a cost-efficient and effective approach to managing runoff and protecting the environment.

Impervious surfaces



Impervious 'hard' surfaces (roofs, roads, large areas of pavement, and asphalt parking lots) increase the volume and speed of stormwater runoff. This swift surge of water erodes streambeds, reduces groundwater infiltration, and delivers many pollutants and sediment to downstream waters.

Pervious surfaces

Pervious 'soft' surfaces (green roofs, rain gardens, grass paver parking lots, and infiltration trenches) decrease volume and speed of stormwater runoff. The slowed water seeps into the ground, recharges the water table, and filters out many pollutants and sediment before they arrive in downstream waters.

Conceptual diagram illustrating impervious and pervious surfaces. Impervious surfaces are hard and increase stormwater runoff, causing pollutant and sediment delivery in downstream waters. Pervious surfaces are soft and decrease stormwater runoff, which filters out pollutants and sediments before they arrive in downstream waters.
Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Chesapeake and Atlantic Coastal Bays Trust Fund, 2013. Stormwater Management: Reducing Water Quantity and Improving Water Quality. IAN press, newsletter publication.

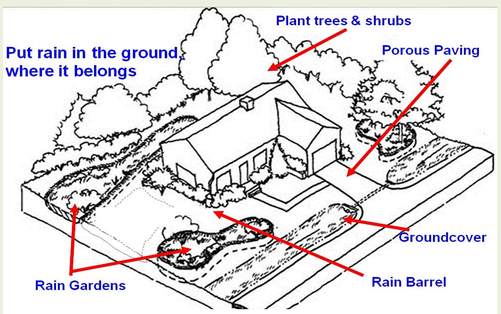
Examples of LID

Rain Gardens

Pervious Pavement

What can you do?

- Use pervious pavement for driveways and walkways
- Install a rain garden or rain barrel
- Plant trees, shrubs and ground covers to reduce runoff from your yard
- Support LID at Town Meeting



This project is funded by a grant from the U.S. Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection (DEP)

Design Consultants, Inc.

120 Middlesex Avenue
Somerville, MA 02145
(617) 776-3350

MEMORANDUM

DCI JOB NO. 2016-055

TO: Danielle Mucciarone
Central Massachusetts Regional Planning Commission
Worcester, MA 01604

FROM: Michael F. Clark, P.E., CPESC, LEED-AP
Robert A. Cahoon, EIT
Design Consultants, Inc.

SUBJECT: **Sturbridge Stormwater Pollution Reduction Project**
Old Sturbridge Village, Sturbridge, MA

DATE: May 3, 2017

Design Consultants, Inc. (DCI) is pleased to provide this Technical Memorandum to the Central Massachusetts Regional Planning Commission (CMRPC) for the above-referenced project. This Technical Memorandum has been prepared in accordance with DCI's proposal dated March 10, 2016, and the contract between the CMRPC and DCI.

The purpose of this project is to assess stormwater conditions at the Old Sturbridge Village main visitor's parking lot, develop a summary of Best Management Practices (BMPs) that will reduce nutrient and sediment loading from the parking lot to the Quinebaug River Reservoir, and develop conceptual designs with cost estimates.

The site location is shown on the Project Locus included as Figure 1.

Background Data

Background information was obtained for each site. Table 1 – Background Data Summary provides a summary of the information obtained. This data was obtained from available online sources, site visits, and information from the Town.

Soils

As shown on Figure 2 – Soils Map, the Natural Resources Conservation Services (NRCS) Soils Map Unit within the main parking lot is 651 – Udorthents, smoothed and 254B - Hinckley loamy sand, 3 to 8 percent slopes for the area surrounding the main parking lot. The parent material for Udorthent soils are made land over firm coarse-loamy basal till and/or dense coarse-loamy lodgment till. Udorthent soils are well-drained and are classified as Hydrologic Soils Group A. The parent material for Hinckley soils are loose sandy and gravelly glacio-fluvial deposits. Hinckley soils are well-drained and are classified as Hydrologic Soils Group A. The infiltration rate for these soils is 2.41 inches per hour[1].

Flood Zones

Both the Quinebaug River and the Quinebaug River Reservoir adjacent to Old Sturbridge Village have designated flood zones. The Quinebaug River to the north of Stallion Hill Road is designated as a Zone AE and the Quinebaug River Reservoir located to the east of Old Sturbridge Village is designated as a Zone A[2]. The Old Sturbridge Village main parking lot and the wetlands associated with these waterbodies that are in close proximity to the parking lot are outside the 100- year flood zone and 500-year flood zone as shown on Figure 3.

Wetlands

MassGIS and the Town's GIS website identify resource areas within the vicinity of the site. Potential resource areas under the Massachusetts Wetland Protection Act Regulations and the Town's Wetland Protection By-Law observed include: Bordering Vegetated Wetlands (Marshes, Swamps, and Bogs); and Rivers or Streams. A small marsh area approximately 125 feet east of the main parking lot driveway and a wooded deciduous swamp on the north side of Stallion Hill Road adjacent to the Quinebaug River were identified on the GIS mapping. Two perennial streams running south to north from Old Sturbridge Village appear to combine and are conveyed under the gravel parking area to the wetland areas through a 36-inch corrugated metal pipe. The extent of the resource areas have not been delineated as part of this project, but the work appears to be limited mostly to the buffer zones associated with these areas. The project site is located within a located within a designated Zone II. The resource areas identified on the MassGIS website are illustrated in Figure 4. Work under this project may require filing a Notice of Intent or Request for Determination of Applicability with the Sturbridge Conservation Commission.

Groundwater

Test pits, borings, and soil evaluations have not been completed as part of this project. A search of the United States Geological Services National Water Information[3] website did not locate wells near the site that could be used to estimate groundwater levels.

[1] Massachusetts Department of Environmental Protection, "Stormwater Handbook, Volume 3: Documenting Compliance with the Massachusetts Stormwater Management Standards Table 2.3.3. 1982 Rawls Rates"
[2] National Flood Insurance Program, Flood Insurance Rate Map, Worcester County, Massachusetts, Panel 926 of 1075, July 4, 2011.
[3] http://maps.waterdata.usgs.gov/mapper

TABLE 1 BACKGROUND DATA SUMMARY	
Background Issue	**Old Sturbridge Village Site**
Soils	• Hinckley Loamy Sand • Udorthents, Smoothed
Infiltration Rate	2.41 inches/hour
Flood Zone	Outside 500 year flood
Wetland	• Resource areas along Stallion Hill Rd • Perennial Streams from Old Sturbridge Village flow through pipe under overflow parking area • Possible work in Buffer Zones
Permitting	Possible filing with Sturbridge Conservation Commission
Groundwater	Data not available

OLD STURBRIDGE VILLAGE MAIN PARKING LOT SITE

The scope of work at the Old Sturbridge Village site consists of the main visitor's parking lot and gravel overflow parking lot off of Stallion Hill Road. The goal of this project is to identify potential alternatives for treatment of stormwater from pipes and direct surface runoff that discharges to the Quinebaug River Reservoir.

Existing Conditions

The existing visitor's parking lot at Old Sturbridge Village is an approximate 10-acre portion of the facility consisting of a paved parking area bisected by the main entry drive, forming a front parking lot with five drive aisles and a rear parking lot with 6 drive aisles. A triangular paved parking area extends to the south off of the main entry drive providing 4 additional drive aisles. Perpendicular parking is provided on each side of the drive aisles, except along site walkways. Approximate 12 foot wide landscape islands separate parking between each of the drive aisles, each consisting of grass or mulch with 2 to 3 trees per island. A gravel overflow parking area without any drive aisle or parking space delineation is provided to the west of the rear parking lot and makes up approximately 40% of the total project area. The site generally slopes from the south to the north, with a change in grade of approximately 23 feet across the site, yielding an average slope of approximately 3.5%. Some of the grade changes occur across the landscaped islands with grade changes of 1-2 feet across the islands. The paved parking lot exhibits puddling along the edges and at the corners of several of the landscaped islands with sediment deposits evident along the observed water paths. Erosion of mulch and soil was also observed along several of the landscaped islands where stormwater runoff cut across the islands.

A review of record site plans and observations from a site visit indicate that there are six (6) existing discharge points from the Old Sturbridge Village main visitor parking area to the nearby resources areas. Stormwater pre-treatment is not currently provided at any of these discharge points, so each of these locations are a primary source of pollutant contribution to the Quinebaug River Reservoir. The Key Plan shown in Figure 5 identifies the six (6) existing discharge points (OS-1 through OS-6) along with 17 locations where evidence of potential sources of stormwater pollution were observed. Photographs of each location are included in Appendix A.

Location 1:
A drop inlet is located on the northerly side of the paved parking lot near Stallion Hill Road. This drop inlet, identified as Outlet Structure No.1 (OS-1), is a corrugated metal pipe drop inlet located directly over the 36-inch corrugated metal pipe carrying the perennial stream to a wetland tributary to the Quinebaug River Reservoir. A paved waterway conveys surface discharge from the paved parking lot directly to the drop inlet.

Location 2:
A grate inlet is located within the gravel overflow parking area near Stallion Hill Road. This grate inlet, identified as Outlet Structure No.2 (OS-2), is located directly over the 36-inch corrugated metal pipe carrying the perennial stream across the parking lot to a wetland area tributary to the Quinebaug River Reservoir. Pollutants and sediment carried in surface runoff are deposited directly into the drainage system.

Locations 3 & 4:
Two landscaped islands in the paved parking lot, west of the main access drive show evidence of the path of stormwater travel and sediment deposits along the berm at the edge of the islands. There are no drainage structures located along these islands or means to collect stormwater runoff. These locations contribute stormwater runoff to OS-1.

Location 5:
Location number 5 is a paved swale through the island to convey water from the high side of the landscaped island northward to the downstream side. Observations indicate that the paved swale transports landscape debris and sediment across the island in a channelized flow, eventually downstream to OS-1.

Location 6:
Outlet Structure No.3 (OS-3) is a drop inlet located off the southerly edge of Stallion Hill Road at the main entrance to Old Sturbridge Village with a stone lined channel directing surface flows to the mouth of the structure. The stone channel exhibits evidence of sediment buildup and erosion along its entire length as well as at the edge of pavement where there are also bits of broken up asphalt. OS-3 discharges through a 12-inch corrugated metal pipe directly to a wetland area east of the Old Sturbridge Village delivery driveway.

Location 7:
A catch basin, identified as Outlet Structure No.4 (OS-4), is located along the main drive at the end of a short gravel egress that provides a connection from the main circulatory drive aisle at the front of the site to the exit. A stone paver channel along the westerly side of the gravel drive directs runoff to the catch basin. There is a buildup of sediment within the stone channel and evidence of sediment tracking at the end of the gravel drive and surrounding the catch basin. Record plans indicate that this catch basin discharges

northward through a 12-inch corrugated metal pipe, although the outlet point is not identified.

Locations 8 & 9:
Located at the northerly edge of the parking lot and at the northwesterly corner of the first island, water stains and sediment buildup provide evidence of puddling. Water is trapped at these corners of the parking lot by the asphalt berm along the edge of the pavement without any drainage structures to collect runoff. A catch basin, which is part of a closed drainage system that conveys water to Outlet Structure No.5 (OS-5), is located at the easterly end of the first island, but it is apparent that the parking lot grading does not adequately convey surface runoff to this system. OS-5 discharges water collected from two (2) catch basins in the front parking lot through a drop inlet along the delivery driveway to a wetland area north of the site that is connected to the Quinebaug River Reservoir.

Locations 10 & 11:
Locations 10 & 11 are two catch basins that are part of a second closed drainage system that was installed as part of a site redevelopment in 2000. According to record plans, this closed drainage system consists of seven (7) catch basins found within the easterly end of the paved parking lot that discharges through a 24 inch corrugated metal pipe to a wetland area north of the site that is connected to the Quinebaug River Reservoir. This pipe also conveys runoff from other collection areas around the Old Sturbridge Village buildings. The outlet for this closed drainage system is identified as Outlet Structure No.6 (OS-6).

Location 12:
A catch basin is located at the northeasterly corner of the southerly paved parking lot, the low point for this section of the parking lot. Sediment buildup is readily apparent around the catch basin, which is connected to OS-6 described above.

Location 13:
Location 13 identifies a water path where stormwater runoff overtops the asphalt berm and spills across the landscaped island to the lower level. Here, a thin layer of mulch, sediment, and landscape debris has been washed onto the pavement. Sediment and debris that makes its way onto the pavement at this location eventually gets washed down to the catch basin at Location 12.

Location 14:
A catch basin is located at the northeasterly corner of the second drive aisle, downgradient of the high side of the water path described for Location 13, above. Sediment buildup and landscape debris were observed around this catch basin, which is connected to the same closed drainage system tributary to OS-6.

Location 15:
A gutter inlet was identified at this location on the southerly, high side of the island, with a small diameter PVC pipe outletting to the lower parking area on northerly side of the island. The pipe daylights approximately 2 feet behind the asphalt berm. A large amount

of sediment buildup and landscape debris were observed around the grate structure of the gutter inlet and erosion and sediment buildup were identified at the outfall pipe.

Locations 16 & 17:
Additional gravel parking spaces are located at the southerly end of the south parking lot on both sides of the paved drive aisle, as well as a restricted employee gravel parking area. This area is at the high point of the site, and it is apparent that these locations are a source of much of the sediment found with the southerly parking lot. Vehicle track marks identify locations where sand and sediment are tracked onto the pavement from the gravel parking areas. This sediment eventually gets washed into the closed drainage system that discharges at OS-6.

Best Management Practice (BMP) Evaluation
Table 2 – BMP Evaluation presents a summary of the evaluation criteria utilized for selecting potential BMPs at the Old Sturbridge Village Site.

When evaluating the BMPs for the site, the first objective was to select BMPs that could be located within available space adjacent to the paved parking areas to minimize the expense of reconstructing or reconfiguring the paved parking area, minimize disruption of the parking lot, and maintain the aesthetics of this popular living museum tourist destination. In addition, the topography and elevations of existing infrastructure and limited areas eliminated many of the larger BMPs such as basins and constructed wetlands.

The next consideration was to identify the BMPs that effectively remove nutrients from stormwater. A review of the data in Table 2 indicated that infiltration and bioretention BMPs would provide the most cost effective treatment.

In order to ensure ease of maintenance with the Old Sturbridge Village facilities maintenance operations, BMPs that required maintenance other than cleaning with a back hoe, vacuum truck, or clam shell were eliminated from the process. This information is summarized on Table 2.

Recommendations
DCI recommends that improvements be made in several areas of the parking lot to reduce or eliminate pollutant sources. These improvements can be prioritized in a manner that will provide the greatest benefit relative to cost. Bioretention is a preferred BMP because in addition to reducing pollutant loads, it promotes infiltration to maintain and increase groundwater levels by adding base flow to local streams, rivers wetlands, and water supply sources. In the interim, it is recommended that Old Sturbridge Village keep up with a regular maintenance plan of cleaning existing catch basins at a minimum of two (2) times per year, sweeping the paved parking lot as needed to control sediment buildup, and plant or mulch landscape islands to minimize sediment runoff. Recommendations, prioritization, and conceptual costs for each of the 17 areas of concern identified in Figure 5 are described below.

TABLE 2
BMP EVALUATION

BMP	Space	Maintenance	Cost (each)	TSS Removal	Nutrient Reduction
Deep Sump Catch Basin	Yes	1	$5,000	25%	TN: 3-6%[4] TP: 1-2%
Oil Grit Separators	Yes	1	>$25,000	25%	TN: 5%[5] TP: 5%
Proprietary Separators	Yes	1	$30,000	30-75%	Varies
Sediment Forebays	Yes	3	$5,000	25%	Limited Data
Vegetated Filter Strips	Yes	2	$5,000	25'-50': 10% >50': 45%	15': 50%[6] 100': 70%
Bioretention Basin	Yes	2	$5,000	90%	TN: 30-50% TP: 30-90%
Tree Filter	Yes	1,2	$15,000	80%	TN: 30-50% TP: 30-90%
Stormwater Wetland	No	2,3	>$25,000	80%	TN: 20-55% TP: 40-60%
Extended Dry Detention Basins	No	3	>$25,000	50%	TN: 15-50% TP: 10-30%
Proprietary Media Filters	Yes	3	>$25,000	Variable	Variable
Sand & Organic Filters	Yes	3	>$25,000	80%	TN: 20-40% TP: 10-50%
Wet Basins	No	3	>$25,000	80%	TN: 10-50% TP: 30-70%
Infiltration Basins	No	3	>$25,000	80%	TN: 50-60% TP: 60-70%
Infiltration Trenches	Yes	3	$5,000	80%	TN: 40-70% TP: 40-70%
Leaching Catch Basins	Yes	1	$5,000	80%	TN: 63-93%[7] TP: 57-92%
Infiltration Structures	Yes	1,2	$5,000	80%	TN: 63-93%[8] TP: 57-92%
Porous Pavement	Yes	3	>$25,000	80%	TN: 99%[9] TP: 99%

Notes:
1. OSV – Maintain with (1) Vac Truck/Clam Shell, (2) Landscape Crew, (3) Other Maintenance
2. Construction Costs

[4] Center for Watershed Protection, "Deriving Reliable Pollutant Removal Rates for Municpal Street Seeping and Storm Drain Cleanout Programs in the Chesapeake Bay Basin:, 2008
[5] Knox County Tennessee Stormwater Management Manual
[6] http://water.epa.gov/polwaste/npdes/swbmp/Vegetated-Filter-Strip.cfm
[7] Center for Watershed Protection, Inc., "Technical Memorandum: The Runoff Reduction Method", April 18, 2008.
[8] Center for Watershed Protection, Inc., "Technical Memorandum: The Runoff Reduction Method", April 18, 2008.
[9] UNH Stormwater Center, "2012 Biennial Report"

Location 1 (OS-1) – *(High Priority)*

OS-1 is a location of high priority because the paved waterway connected to the drop inlet located over the 36-inch corrugated metal pipe carrying the perennial stream to the Quinebaug River Reservoir provides a direct sheet flow of surface runoff and pollutants from approximately 3 acres of the rear parking lot, including approximately 0.5 acres of the gravel overflow parking area. The paved waterway and open land at the edge of the parking lot provide an ideal location for a sediment forebay with bioretention area the can be easily inspected and cleaned by Old Sturbridge Village maintenance crews as necessary. It is further recommended that the corrugated metal pipe drop inlet over the 36-inch corrugated metal pipe be replaced with a doghouse style manhole to allow an overflow outlet control structure installed in the bioretention area to be connected while minimizing flow of pollutants into the system. Because this area alone is not adequate to provide stormwater pretreatment for the entire 3 acre rear parking lot, it is recommended that additional stormwater pretreatment measures be implemented to support this system as outlined under Locations 3, 4, and 5, below.

Location 2 (OS-2) – *(High Priority)*

OS-2 is a location of high priority because the inlet grate located directly over the 36-inch corrugated metal within the gravel overflow parking lot provides an extremely high source of pollutant contributions directly to the perennial stream and Quinebaug River Reservoir. Short of paving the 3-acre overflow parking lot to minimize erosion of the gravel to Reservoir, it is recommended that the inlet structure be removed and replaced with a manhole with cover over the existing pipe to eliminate the direct surface discharge to the pipe and a stone lined sedimentation basin with an overflow structure be constructed to capture sediment before stormwater is discharged to the pipe.

Locations 3, 4 & 5 - *(Medium Priority)*

The landscaped islands provide an ideal location to provide stormwater improvements, particularly in the large rear parking lot area where stormwater runoff collection is non-existent. It is recommended that bioretention areas be installed in the landscaped islands identified in Locations 3, 4, and 5. These bioretention areas, identified as "Type B" in this report, would consist of sections of granite curbing set about 1 to 2 inches below the edge of pavement to allow stormwater to sheet flow into the treatment area. The stormwater would then flow into a 1-foot wide stone trench to spread out the flows and slow the erosive velocity of water entering the bioretention area. The bioretention areas should be 6 to 8 feet wide, and may need to be stepped with granite curbing depending upon the grade change across the islands. The length of the bioretention areas is dependent upon the length of the islands and presence of existing trees. Since there are no existing drainage systems located within the rear parking lot, these bioretention areas would overflow back onto the pavement and downstream to the next island. While these improvements are only identified at three locations in the rear parking lot where contributions of source pollutants were evident, this treatment could be installed at all landscape islands where conditions permit to reduce sheet flows reaching OS-1 at Location 1, reducing the size of the BMPs at OS-1.

Location 6 (OS-3) – *(Medium Priority)*

The drop inlet located at Location 6 collects stormwater runoff from a much smaller area, approximately 0.3 acres, from the site parking lot access drive and Stallion Hill Road. It is recommended that the existing stone channel and drop inlet be replaced by a small sediment forebay with a bioretention area. The limits of the Stallion Hill Road right-of-way will need to be determined to locate this stormwater feature. Additionally, the gravel driveway exiting the front parking lot is a significant source of sediment tracking and should either be paved, porous pavement such as GravelPave®, or loamed and seeded to reduce sediment contributions to the watershed.

Location 7 – *(Medium Priority)*

Similar to Location 6, the catch basin at Location 7 collects stormwater runoff from a relatively small area, approximately 0.4 acres. The catch basin provides some pretreatment of collected stormwater before it is conveyed offsite to an unknown location. It is recommended that a small stone forebay and bioretention area be constructed to provide improved pretreatment of stormwater in this area. Paving or loaming and seeding the existing gravel drive mentioned above will significantly reduce the erosion and sediment tracking into this catch basin.

Location 8 – *(Low Priority)*

Although there was evidence of ponding, erosion, and sediment buildup in this area, Location 8 is a low priority because the stormwater runoff gets trapped and is not directly discharged into any system. It is recommended that a bioretention area be constructed adjacent to the paved parking lot. A granite curb set 1 to 2 inches below the edge of pavement would allow the water to flow off the pavement into a stone channel spreader prior to flowing into the bioretention area. These improvements would reduce sediment tracking and extend the life of the pavement which will be shortened by the presence of water ponding on the surface.

Location 9 – *(Low Priority)*

Similar to Location 8, this location is a low priority because stormwater runoff gets trapped at the northwest corner of the island. Due to the location of an existing tree near this corner, it is recommended that a small bioretention area be installed at the end of the island.

Location 10, 11, 12 & 14 – *(Medium Priority)*

It is recommended that the existing catch basins at these four locations be retrofitted to include leaching basins. Additionally, DCI recommends that existing catch basins that are in poor condition or provide minimal sump be replaced with a deep sump catch basin with a hood, and be connected to a leaching basin. The invert of the pipe connecting the deep sump catch basin with the leaching catch basin should be at or below the existing invert of each catch basin. The existing outlet could be bricked up to create a weir that would allow overflow from the catch basin once the leaching basin is at capacity. The distance from the top of the weir to the invert of the inlet pipe into the leaching basin can be determined after further design. A typical configuration is shown in Appendix D.

Location 13 & 15 – *(Medium Priority)*

Location 13 is a spot where stormwater ponds on the high side of the island before spilling over the berm and running across the landscape island. It is recommended that a bioretention area be installed in this island with a piece of curbing be installed 1 to 2 inches below the edge of pavement with a 1-foot wide stone channel spreader to disperse the flow prior to entering the bioretention area. These improvements would reduce the flow of sediment flowing to the closed drainage system described in Locations 10, 11, 12 & 14 above.

In order to verify our recommendations, the recommended systems have been modeled using HydroCAD®. The calculations show that the entire Water Quality Volume (32,135 cubic feet) based on 1-inch depth for discharges within a Zone II, can be infiltrated on site. DCI also calculated the Pollutant Reduction for each outlet control point based on the Simple Method. The total resulting pollutant removal is as follows:

Total Suspended Solids (TSS):	21,480 lbs
Total Phosphorus (TP):	14.75 lbs
Total Nitrogen (TN):	83.30 lbs

Additional Information Required

In order to bring the design of the selected BMPs to a level where the project can be publicly bid in accordance with Chapter 30B of the Massachusetts General Laws, the following additional information is required:

- Topographic and Property Line Survey
- Geotechnical testing to confirm soil conditions and groundwater depths

Costs

Table 3 below presents the preliminary cost estimate for this work.

TABLE 3
COST EVALUATION

Location	Recommended Improvements	Estimated Cost
1	Sediment Forebay with Bioretention Area.....	$ 23,000
2	Stone Lined Drainage Basin.....	$ 17,000
3	Bioretention Area – Type B (130 ft @ $110/ft).....	$ 14,300
4	Bioretention Area – Type B (100 ft @ $110/ft).....	$ 11,000
5	Bioretention Area – Type B (50 ft @ $110/ft).....	$ 5,500
6	Stone Forebay with Bioretention Area…….....	$ 10,100
7	Stone Forebay with Bioretention Area & Drive Paving.....	$ 22,200
8	Bioretention Area – Type B (50 ft @ $110/ft)……..	$ 5,500
9	Bioretention Area – Type B (25 ft @ $110/ft)……..	$ 2,750
10	Leaching Basin (1 EA @ $7,500)……	$ 7,500
11	Leaching Basin (1 EA @ $7,500)……	$ 7,500
12	Leaching Basin (1 EA @ $7,500)……	$ 7,500
13	Bioretention Area – Type B (50 ft @ $110/ft)……..	$ 5,500
14	Leaching Basin (1 @ $7,500)……..	$ 7,500
15	Bioretention Area – Type B (40 ft @ $110/ft)……..	$ 4,400
	Construction Subtotal	*$ 141,350*
	Permitting (Notice of Intent)	$ 5,000
	Survey	TBD
	Design Drawings	TBD
	Specifications	$ 3,000
	Construction Observation & As-Built	TBD
	Design Subtotal	*$*
	Total Project Cost	

Cost per pound TSS:	$7/lb	(Subject to change, depending upon
Cost per pound TP:	$9,600/lb	selected alternatives and design costs)
Cost per pound TN:	$1,700/lb	

Additional Considerations

During the evaluation of the Old Sturbridge Village main parking lot, it was apparent that the overflow parking lot, gravel parking area in the southerly parking lot, and the gravel employee parking area are subjected to consistent use, which has resulted in erosion of the gravel driving and parking surfaces. In order to quantify this erosion, the gravel overflow parking area soil loss due to erosion was calculated with the Revised Universal Soil Loss Equation (RUSLE) for the portion tributary to Location 1 (OS-1) and the area tributary to Location 2 (OS-2). The soil loss for these two areas was estimated to be approximately 82,100 pounds (41 tons) per year from erosion. Additional amounts can be attributed to vehicle operation on the surface. These

additional volumes of material are difficult to quantify, but the effect overtime can be documented by the sediment tracking along the paved surfaces and sediment buildup at low points.

Locations 16 and 17 represent gravel parking areas on the southerly edge of the parking lot and employee parking areas respectively. The compacted gravel provides limited infiltration and high erosion and sediment tracking. Since these areas are located on the high side of the site, these locations provide a significant volume of sediment runoff into the closed drainage system outletting to OS-6. While out of the scope of this study, in order to minimize the ongoing erosion and its resulting non-point source (NPS) pollution, it is recommended that consideration be given to treat these areas with a porous surface such as Gravel Pave over 12-inches of crushed stone. This porous surface would infiltrate surface runoff at a shallow depth and prevent erosion of the surface areas.

Attachments:

Figure 1 – Project Locus
Figure 2 – Soils Maps
Figure 3 – Firmette
Figure 4 – GIS Resource Areas
Figure 5 – Location Key Plan

Appendix A – Photographs
Appendix B – Stormwater Calculations
Appendix C – RUSLE Calculations
Appendix D – BMP Designs

NOTES

1. THIS PLAN IS PREPARED ON AN AERIAL BASE MAP OBTAINED FROM BING MAPS © 2016 MICROSOFT CORPORATION.
2. ALL DIMENSIONS SHOWN ARE APPROXIMATE FOR CONCEPTUAL PURPOSES ONLY.

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PROJECT LOCUS
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

PREPARED FOR:
CMRPC

PROJECT #: 2016-055
PROJECT MGR: MFC
SURVEYOR:
DRAFTED BY: RAC
CHECKED BY:
FIGURE:

1

OF 5 REV.

P:\2016 PROJECTS\2016-055 STURBRIDGE VILLAGE STORMWATER\DWG_ENGINEERING\AERIAL SCHEMATIC PLAN.DWG

Figure 2. Soils Map

Soil Map—Worcester County, Massachusetts, Southern Part
(Old Sturbridge Village)

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Worcester County, Massachusetts, Southern Part
Survey Area Data: Version 8, Sep 28, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

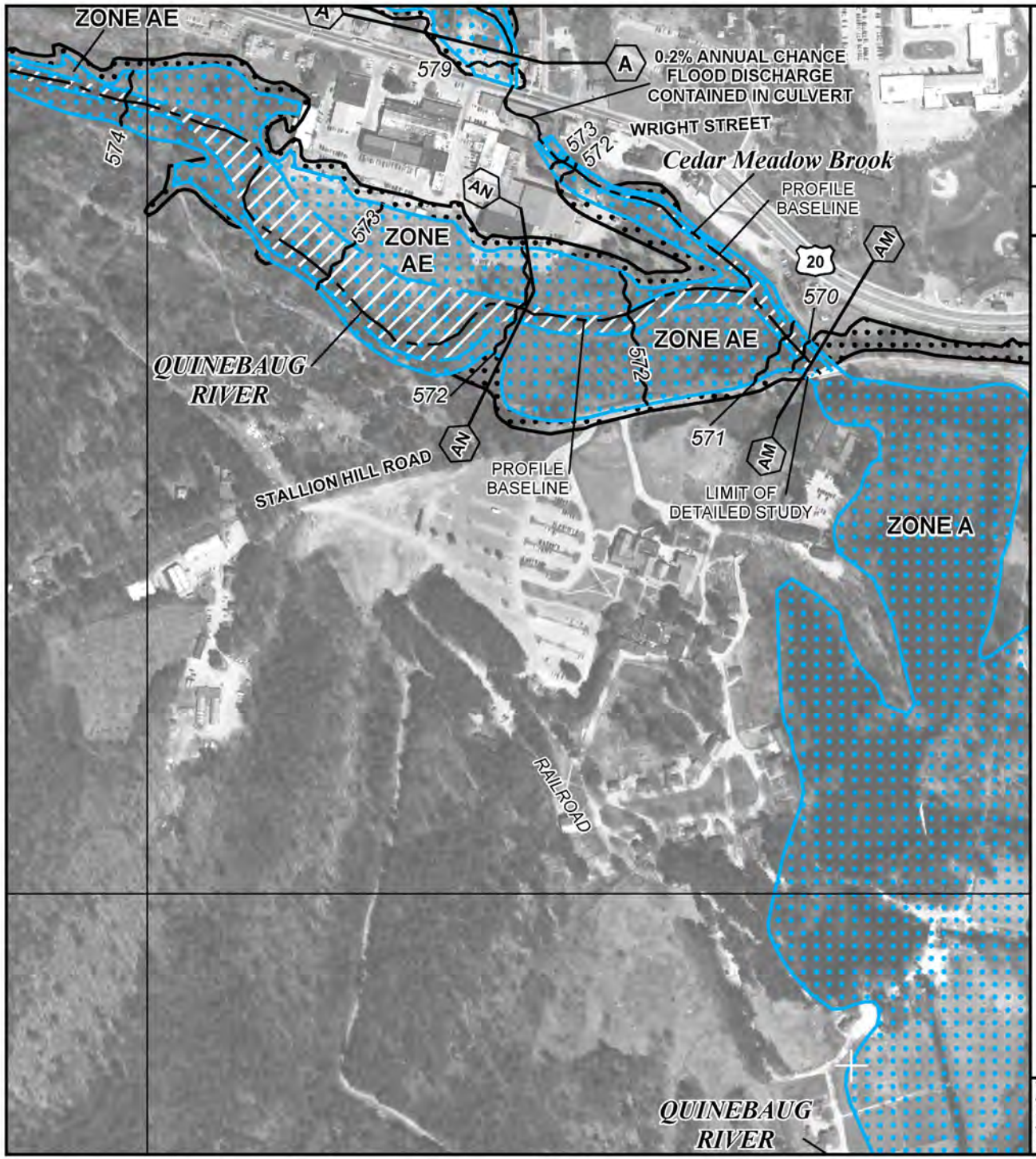
Date(s) aerial images were photographed: Apr 8, 2011—May 12, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Worcester County, Massachusetts, Southern Part (MA615)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
1	Water	0.1	0.2%
3A	Scarboro and Walpole soils, 0 to 3 percent slopes	0.6	1.8%
102C	Chatfield-Hollis-Rock outcrop complex, 3 to 15 percent slopes	0.0	0.0%
245B	Hinckley loamy sand, 3 to 8 percent slopes	17.3	56.6%
245C	Hinckley loamy sand, 8 to 15 percent slopes	3.5	11.4%
307B	Paxton fine sandy loam, 0 to 8 percent slopes, extremely stony	0.4	1.2%
312B	Woodbridge fine sandy loam, 0 to 8 percent slopes, extremely stony	0.8	2.5%
651	Udorthents, smoothed	8.0	26.2%
Totals for Area of Interest		**30.5**	**100.0%**

Figure 3. Firmette



MAP SCALE 1" = 500'

250 0 500 1000 FEET

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0926E

FIRM

FLOOD INSURANCE RATE MAP

WORCESTER COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

PANEL 926 OF 1075

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
STURBRIDGE, TOWN OF	250337	0926	E

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

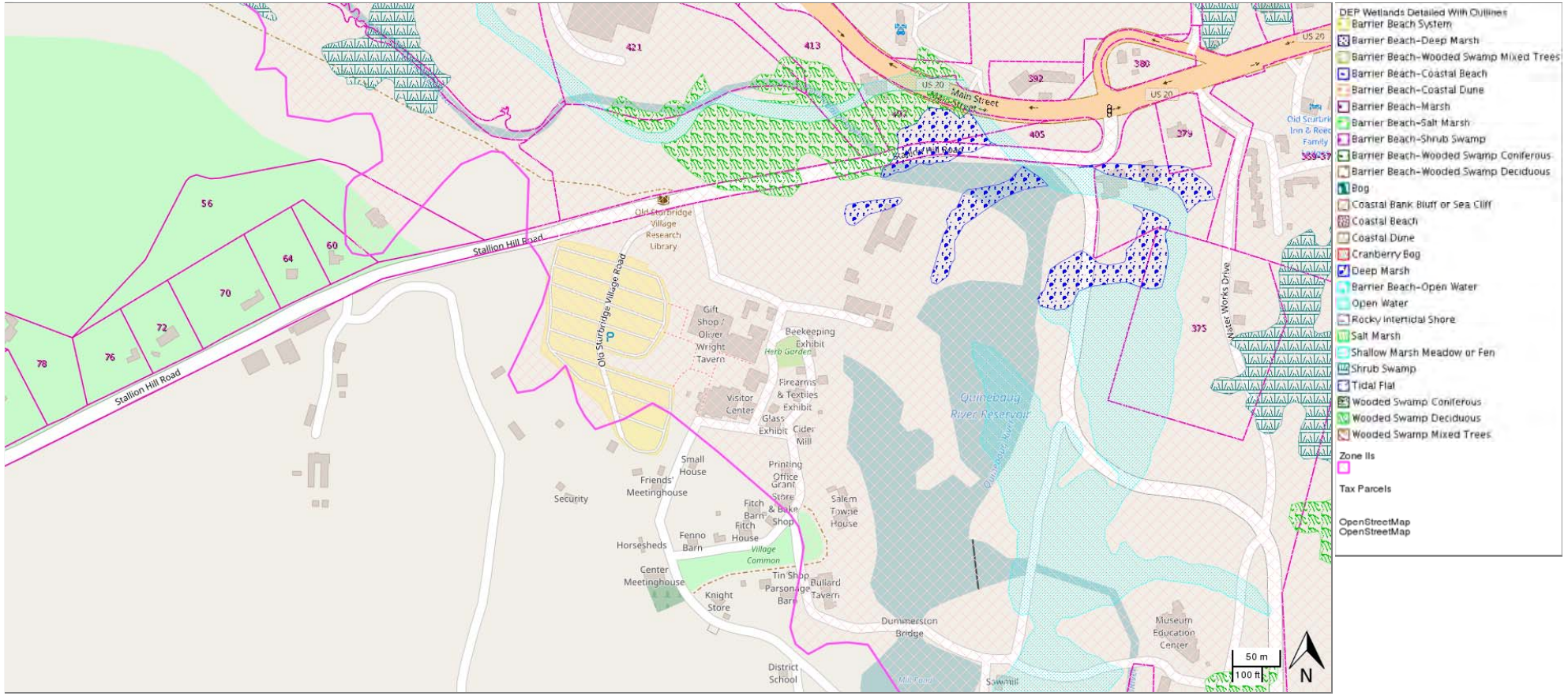
MAP NUMBER
25027C0926E

EFFECTIVE DATE
JULY 4, 2011

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

Figure 4. GIS Resource Areas



NOTES

1. THIS PLAN IS PREPARED ON AN AERIAL BASE MAP OBTAINED FROM BING MAPS © 2016 MICROSOFT CORPORATION.
2. ALL DIMENSIONS SHOWN ARE APPROXIMATE FOR CONCEPTUAL PURPOSES ONLY.

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KEY PLAN
OLD STRUBRIDGE VILLAGE
STURBRIDGE, MA

PREPARED FOR:
CMRPC

PROJECT #:	2016-055
PROJECT MGR:	MFC
SURVEYOR:	
DRAFTED BY:	RAC
CHECKED BY:	

FIGURE:

5

OF 5 REV.

P:\2016 PROJECTS\2016-055 STURBRIDGE VILLAGE STORMWATER\DWG_ENGINEERING\AERIAL SCHEMATIC PLAN.DWG

Appendix A

Photographs

Photo #1 Description:
Water path along island in rear paved parking lot identified as Location 4.

DCI photograph
July 1, 2016

Photo #2 Description:
Paved swale across island in rear of paved parking lot identified in Location 5.

DCI photograph
July 1, 2016

Photo #3 Description:
Paved swale across island in rear of paved parking lot identified in Location 5.

DCI photograph
July 1, 2016

Photo #4 Description:
Catch basin in the gravel overflow parking area described in Location 2.

DCI photograph
July 1, 2016

Photo #5 Description:
Paved waterway to outlet structure OS-1 described in Location 1.

DCI photograph
July 1, 2016

Photo #6 Description:
Water path along edge of landscaped island described in Location 3.

DCI photograph
July 1, 2016

Photo #7 Description:
Water path along edge of parking lot leading to outlet structure OS-1 described in Location 1.

DCI photograph
July 1, 2016

Photo #8 Description:
Paved waterway to outlet structure OS-1 described in Location 1.

DCI photograph
July 1, 2016

Photo #8.1 Description:
A look inside the drop inlet at outlet structure OS-1 described in Location 1.

DCI photograph
July 1, 2016

Photo #8.2 Description:
A look at the outside of the drop inlet at outlet structure OS-1 described in Location 1.

DCI photograph
July 1, 2016

Photo # 9 Description:
A look across the front parking lot area towards the front entrance of Old Sturbridge Village as described in Location 8.

DCI photograph
July 1, 2016

Photo # 10 Description:
A look at the corner of the front parking lot area described in Location 8.

DCI photograph
July 1, 2016

Photo #11 Description:
Looking northwest at the corner of the first landscape island in the front parking area as described in Location 9.

DCI photograph
July 1, 2016

Photo #12 Description:
Looking north at the corner of the first landscape island in the front parking area as described in Location 9.

DCI photograph
July 1, 2016

Photo #13 Description:
Looking north at CB-1 in the corner of the second landscape island in the front parking area as described in Location 10.

DCI photograph
July 1, 2016

Photo #14 Description:
Looking west at CB-2 in the corner of the fourth landscape island in the front parking area as described in Location 11

DCI photograph
July 1, 2016

Photo #15 Description:
Close up view of CB-2 shown in Photo #14

DCI photograph
July 1, 2016

Photo #16 Description:
Looking east at CB-3 in the northeast corner of the southerly parking lot as described in Location 12.

DCI photograph
July 1, 2016

Photo #17 Description:
Close up view of CB-3 shown in Photo #16 and described in Location 12.

DCI photograph
July 1, 2016

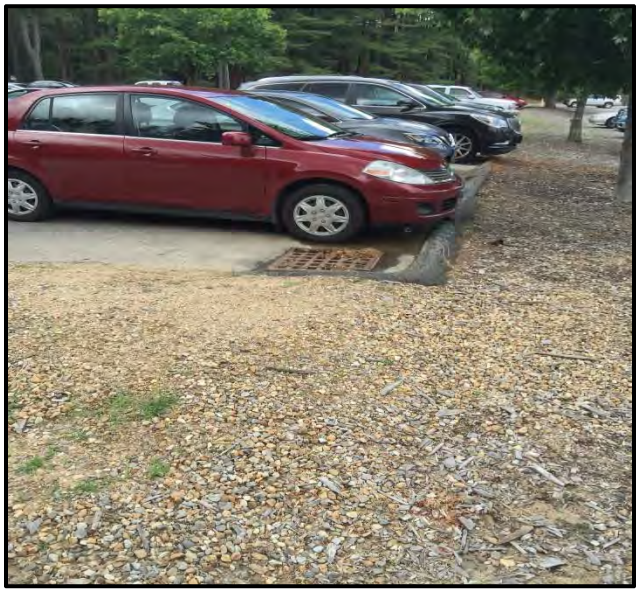

Photo #18 Description:
Looking westerly at CB-4 in the southerly parking lot as described in Location 14.

DCI photograph
July 1, 2016

Photo #19 Description:
Water path cutting across the first island in the southerly parking lot as described in Location 13.

DCI photograph
July 1, 2016

Photo #20 Description:
Island treatment in the southerly parking lot.

DCI photograph
July 1, 2016

Photo #21 Description:
Side view of water path across the first landscape island in the southerly parking lot.

DCI photograph
July 1, 2016

Photo #22 Description:
Front view of water path across the first landscape island in the southerly parking lot.

DCI photograph
July 1, 2016

Photo #23 Description:
Side view of water path across the first landscape island in the southerly parking lot.

DCI photograph
July 1, 2016

Photo #24 Description:
View of gutter inlet in southerly parking lot as described in Location 15.

DCI photograph
July 1, 2016

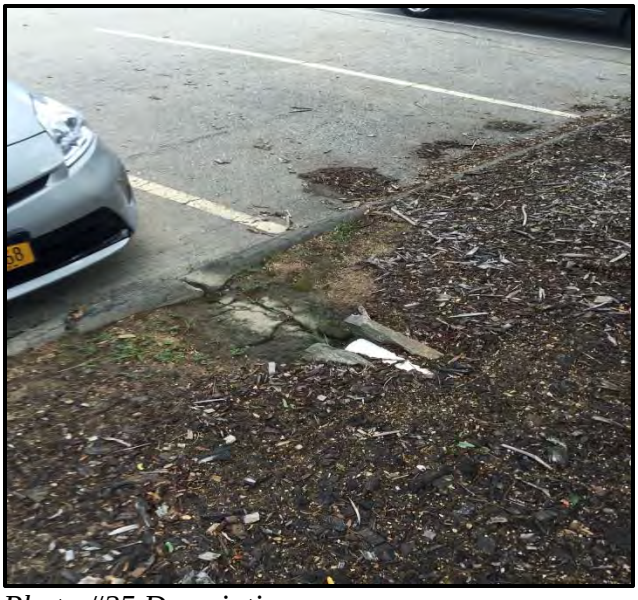

Photo #25 Description:
PVC outfall pipe from gutter inlet shown in Photo #24 and described under Location 15.

DCI photograph
July 1, 2016

Photo #26 Description:
Side view of gutter inlet with PVC outfall pipe shown in Photos #24 & #25 and as described in Location 15.

DCI photograph
July 1, 2016

Photo #27 Description:
Close up view of top of gutter inlet shown in Photo #24.

DCI photograph
July 1, 2016

Photo #28 Description:
Stone paver gutter line along one of the landscaped islands in the southerly parking lot.

DCI photograph
July 1, 2016

Photo #29 Description:
Looking south at catch basin OS-4 on the main exit drive at the end of the gravel access drive as described in Location 7.

DCI photograph
July 1, 2016

Photo #30 Description:
Looking easterly along Stallion Hill Road at drop inlet OS-3 located at the entrance to Old Sturbridge Village as described in Location 6.

DCI photograph
July 1, 2016

Photo #31 Description:
Looking westerly along Stallion Hill Road at the stone paver channel leading to drop inlet OS-3 shown in Photo #30.

DCI photograph
July 1, 2016

Appendix B

Stormwater Calculations

CALCULATIONS

Outlet Structure No. 1 (OS-1) – Location 1

Photo 1 - View of Outlet Structure


Photo 2 – Flow into OS-1

Impervious Drainage Area = 116,500± SF
Length of Drainage Path = 750± FT
Change in Elevation = 17± SF

Water Quality Volume based on 1-inch[1] = 9,710 CF

From Soil Survey: 245B—Hinckley loamy sand, 3 to 8 percent slopes[2]
Hydrologic Soil Group "A"

Infiltration Rate[3]: 2.41 inches/ hour

Recommendation – Bioretention with Sediment Forebay at outfall with Bioretention Swales at Locations 3, 4 & 5. This design provides a treatment train that uses existing landscaped areas and allows for visual inspection and ease of cleaning by Old Sturbridge Village maintenance staff as needed.

Other Options - Infiltration Structure; Infiltration Basin

Sediment Forebay Volume[4] Vol = 0.1 inches x 116,500 SF = 970 CF

TSS Removal = 12,060 lbs
Phosphorus Removal = 6.55 lbs
Nitrogen Removal = 35.1 lbs
Conceptual Capital Cost = $53,800

[1] MA DEP, "Stormwater Handbook Volume 3, Chapter 1 – Documenting Compliance", Page 32"
[2] http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
[3] MA DEP, "Stormwater Handbook Volume 3, Chapter 1 – Documenting Compliance, Table 2.3.3. 1982 Rawls Rates"
[4] MA DEP, "Volume 2 Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook", Page 15

CALCULATIONS

Outlet Structure No. 2 (OS-2) – Location 2

Photo 1 - View of Outlet Structure OS-2

Impervious Drainage Area = 130,700± SF
Length of Drainage Path = 500± FT
Change in Elevation = 15± SF

Water Quality Volume based on 1-inch[5] = 10,900 CF

From Soil Survey: 245B—Hinckley loamy sand, 3 to 8 percent slopes[6]
Hydrologic Soil Group "A"

Infiltration Rate[7]: 2.41 inches/ hour

Recommendation – Stone Lined Drainage Basin – This design considers that the unimproved 3-acre overflow parking area will remain as is. The open basin will allow sediment contained in the runoff to settle out before entering the existing drainage system.

Other Options - Proprietary Structure w/ Infiltration Structure; Parking Lot Paving

Sediment Forebay Volume[8] Vol = 0.1 inches x 130,700 SF = 1,100 CF

TSS Removal = 1,624 lbs
Phosphorus Removal = 3.38 lbs
Nitrogen Removal = 20.3 lbs
Conceptual Capital Cost = $17,000

[5] MA DEP, "Stormwater Handbook Volume 3, Chapter 1 – Documenting Compliance", Page 32"
[6] http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
[7] MA DEP, "Stormwater Handbook Volume 3, Chapter 1 – Documenting Compliance, Table 2.3.3. 1982 Rawls Rates"
[8] MA DEP, "Volume 2 Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook", Page 15

CALCULATIONS

Outlet Structure No. 3 (OS-3) - Location 6

Photo 1 – Stone waterway to Drop Inlet

Impervious Drainage Area = 14,600± SF
Length of Drainage Path = 400± FT
Change in Elevation = 12± SF

Water Quality Volume based on 1-inch[9] = 1,025 CF

From Soil Survey: 245B—Hinckley loamy sand, 3 to 8 percent slopes[10]
Hydrologic Soil Group "A"

Infiltration Rate[11]: 2.41 inches/ hour

Recommendation – Bioretention with Sediment Forebay – Groundwater is expected to be shallow due to proximity to the nearby wetlands. A surface system allows stormwater to be treated effectively and provide ease of inspection and maintenance by Old Sturbridge Village maintenance staff or Sturbridge Public Works Department.

Other Options - Infiltration Structure; Infiltration Basin

Sediment Forebay Volume[12] Vol = 0.1 inches x 12,300 SF = 105 CF

TSS Removal = 1,593 lbs
Phosphorus Removal = 0.86 lbs
Nitrogen Removal = 4.6 lbs
Conceptual Capital Cost = $10,100

[9] MA DEP, "Stormwater Handbook Volume 3, Chapter 3 – Documenting Compliance", Page 32"
[10] http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
[11] MA DEP, "Stormwater Handbook Volume 3, Chapter 1 – Documenting Compliance, Table 2.3.3. 1982 Rawls Rates"
[12] MA DEP, "Volume 2 Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook", Pg 15

CALCULATIONS

Outlet Structure No. 4 (OS-4) – Location 7

Photo 1 – Catch Basin on entry drive at end of gravel drive

Impervious Drainage Area = 11,900± SF
Length of Drainage Path = 230± FT
Change in Elevation = 9± SF

Water Quality Volume based on 1-inch[13] = 1,000 CF

From Soil Survey: 245B—Hinckley loamy sand, 3 to 8 percent slopes[14]
Hydrologic Soil Group "A"

Infiltration Rate[15]: 2.41 inches/ hour

Recommendation – Bioretention with Sediment Forebay and Pave or Eliminate Gravel Drive – Eliminating the gravel drive will significantly reduce sediment loading at this catch basin and at OS-3 by eliminating erosion and sediment tracking. A Bioretention area with a sediment forebay provides for easy maintenance.

Other Options - Infiltration Structure; Infiltration Basin

Sediment Forebay Volume[16] Vol = 0.1 inches x 11,900 SF = 100 CF

TSS Removal = 486 lbs
Phosphorus Removal = 0.26 lbs
Nitrogen Removal = 1.4 lbs
Conceptual Capital Cost = $22,200

[13] MA DEP, "Stormwater Handbook Volume 3, Chapter 1 – Documenting Compliance", Page 32"
[14] http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
[15] MA DEP, "Stormwater Handbook Volume 3, Chapter 1 – Documenting Compliance, Table 2.3.3. 1982 Rawls Rates"
[16] MA DEP, "Volume 2 Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook", Pg 15

CALCULATIONS

Outlet Structure No. 5 (OS-5)

Photo 1 – Closed drainage system in front parking lot leading to Outlet Structure No. 5 (OS-5).

Impervious Drainage Area = 18,200± SF
Length of Drainage Path = 240± FT
Change in Elevation = 4± SF

Water Quality Volume based on 1-inch[17] = 1,500 CF

From Soil Survey: 245B—Hinckley loamy sand, 3 to 8 percent slopes[18]
Hydrologic Soil Group "A"

Infiltration Rate[19]: 2.41 inches/ hour

Recommendation – Leaching basins connected to the two existing catch basins in the front driveway would provide pollutant removal from OS-5. These locations were not observed to be problematic areas during a site visit.

Other Options - Proprietary separator prior to outlet structure

Sediment Forebay Volume[20] Vol = 0.1 inches x 18,200 SF = 150 CF

TSS Removal = Not Calculated
Phosphorus Removal = Not Calculated
Nitrogen Removal = Not Calculated
Conceptual Capital Cost = No improvements included at this time.

[17] MA DEP, "Stormwater Handbook Volume 3, Chapter 1 – Documenting Compliance", Page 32"
[18] http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
[19] MA DEP, "Stormwater Handbook Volume 3, Chapter 1 – Documenting Compliance, Table 2.3.3. 1982 Rawls Rates"
[20] MA DEP, "Volume 2 Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook", Pg 15

CALCULATIONS

Outlet Structure No. 6 (OS-6)

Photo 1 – Catch basin at end of closed drainage system in front of building leading to Outlet Structure No. 6 (OS-6)

Impervious Drainage Area = 95,300± SF
Length of Drainage Path = 750± FT
Change in Elevation = 17± SF

Water Quality Volume based on 1-inch[21] = 8,000 CF

From Soil Survey: 245B—Hinckley loamy sand, 3 to 8 percent slopes[22]
Hydrologic Soil Group "A"

Infiltration Rate[23]: 2.41 inches/ hour

Recommendation – Leaching Basins & Bioretention Areas – These alternatives provide the best retrofit alternative to the existing closed drainage system and landscape islands while minimizing disruption to the front parking areas

Other Options - Proprietary separator prior to outlet

Sediment Forebay Volume[24] Vol = 0.1 inches x 95,300 SF = 800 CF

TSS Removal = 5,663 lbs
Phosphorus Removal = 3.56 lbs
Nitrogen Removal = 20.9 lbs
Conceptual Capital Cost = $39,900

[21] MA DEP, "Stormwater Handbook Volume 3, Chapter 1 – Documenting Compliance", Page 32"
[22] http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
[23] MA DEP, "Stormwater Handbook Volume 3, Chapter 1 – Documenting Compliance, Table 2.3.3. 1982 Rawls Rates"
[24] MA DEP, "Volume 2 Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook", Pg 15

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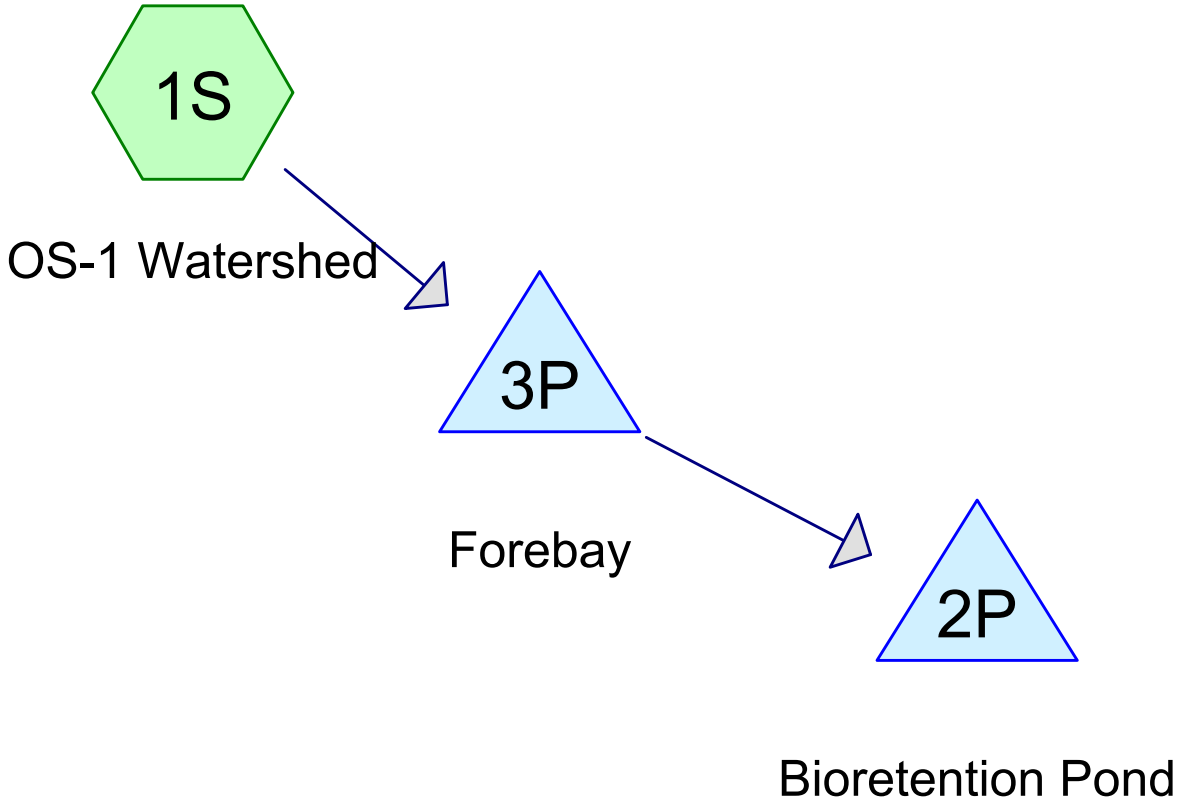
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 1

DCI PROJECT: 2016-055



Subcat Reach Pond Link

Drainage Diagram for OSV OC-1
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.807	98	Paved parking, HSG A (1S)
1.807		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
1.807	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
1.807		**TOTAL AREA**

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: OS-1 Watershed Runoff Area=78,700 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=1.61 cfs 0.119 af

Pond 2P: Bioretention Pond Peak Elev=581.71' Storage=1,954 cf Inflow=1.60 cfs 0.100 af
Discarded=0.09 cfs 0.085 af Primary=0.38 cfs 0.015 af Outflow=0.47 cfs 0.100 af

Pond 3P: Forebay Peak Elev=581.07' Storage=880 cf Inflow=1.61 cfs 0.119 af
Outflow=1.60 cfs 0.100 af

Total Runoff Area = 1.807 ac Runoff Volume = 0.119 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 1.807 ac

Summary for Subcatchment 1S: OS-1 Watershed

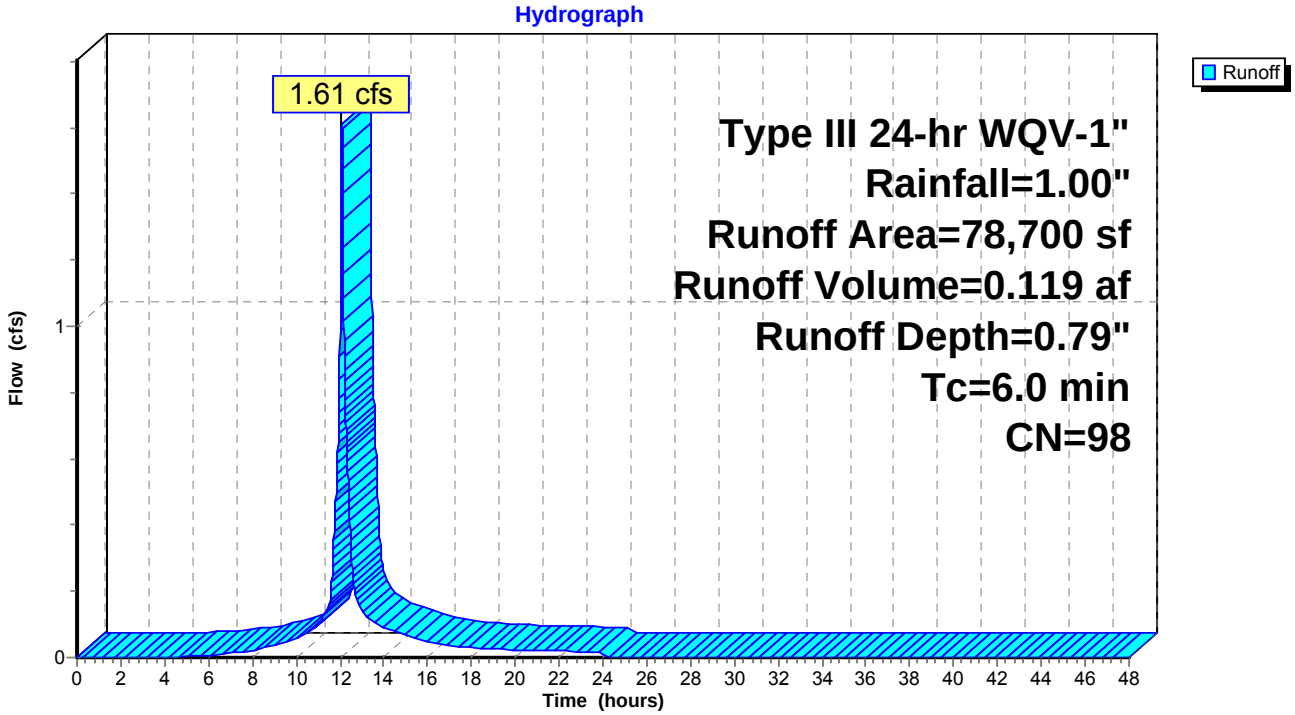
Runoff = 1.61 cfs @ 12.08 hrs, Volume= 0.119 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

Area (sf)	CN	Description
78,700	98	Paved parking, HSG A
78,700		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Subcatchment 1S: OS-1 Watershed



Summary for Pond 2P: Bioretention Pond

[81] Warning: Exceeded Pond 3P by 0.68' @ 12.45 hrs

Inflow Area = 1.807 ac,100.00% Impervious, Inflow Depth = 0.66" for WQV-1" event
Inflow = 1.60 cfs @ 12.09 hrs, Volume= 0.100 af
Outflow = 0.47 cfs @ 12.43 hrs, Volume= 0.100 af, Atten= 71%, Lag= 20.4 min
Discarded = 0.09 cfs @ 12.43 hrs, Volume= 0.085 af
Primary = 0.38 cfs @ 12.43 hrs, Volume= 0.015 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 581.71' @ 12.43 hrs Surf.Area= 1,224 sf Storage= 1,954 cf

Plug-Flow detention time= 249.8 min calculated for 0.100 af (100% of inflow)
Center-of-Mass det. time= 249.7 min (1,077.8 - 828.1)

Volume	Invert	Avail.Storage	Storage Description
#1	579.00'	3,994 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

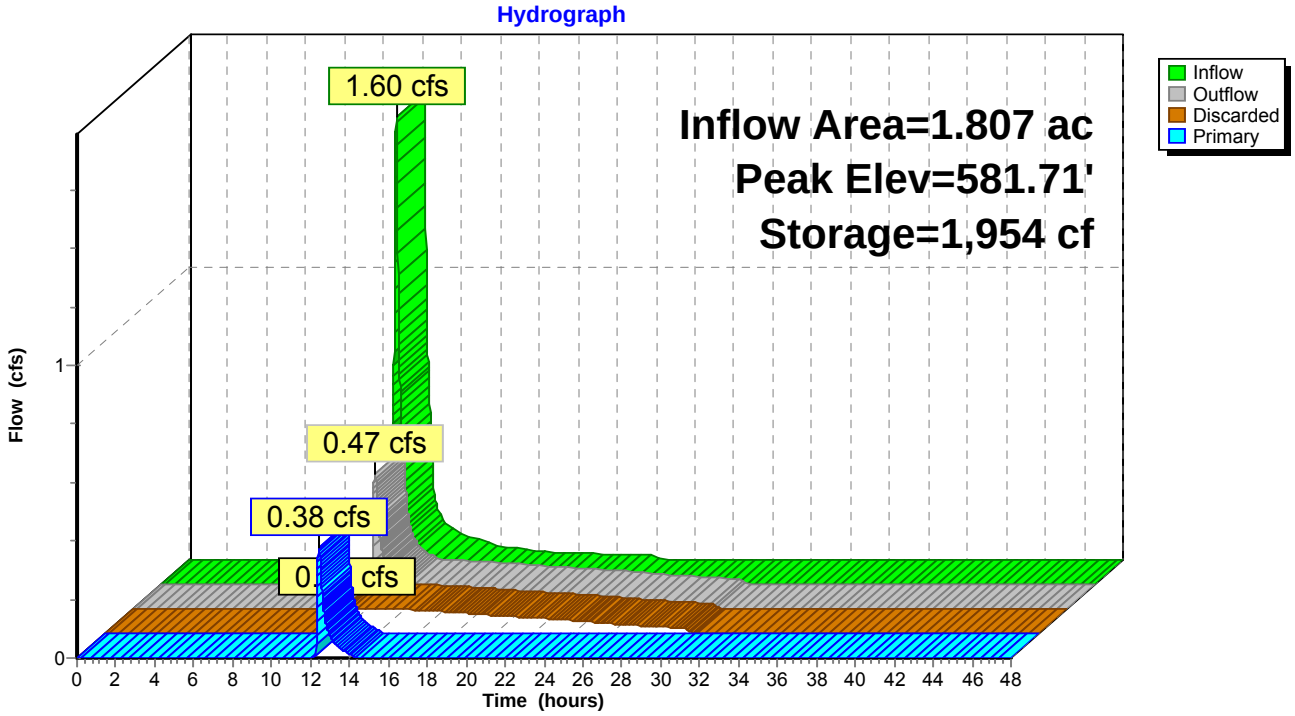
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
579.00	300	0	0
580.00	576	438	438
581.00	924	750	1,188
582.00	1,344	1,134	2,322
583.00	2,000	1,672	3,994

Device	Routing	Invert	Outlet Devices
#1	Primary	581.60'	**3.0' long Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	579.00'	**2.410 in/hr Exfiltration over Horizontal area above 578.00'** Conductivity to Groundwater Elevation = 574.00' Excluded Horizontal area = 0 sf Phase-In= 0.01'

Discarded OutFlow Max=0.09 cfs @ 12.43 hrs HW=581.71' (Free Discharge)
↑**2=Exfiltration** (Controls 0.09 cfs)

Primary OutFlow Max=0.37 cfs @ 12.43 hrs HW=581.71' (Free Discharge)
↑**1=Sharp-Crested Vee/Trap Weir** (Weir Controls 0.37 cfs @ 1.10 fps)

Pond 2P: Bioretention Pond



Summary for Pond 3P: Forebay

Inflow Area = 1.807 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 1.61 cfs @ 12.08 hrs, Volume= 0.119 af
Outflow = 1.60 cfs @ 12.09 hrs, Volume= 0.100 af, Atten= 0%, Lag= 0.3 min
Primary = 1.60 cfs @ 12.09 hrs, Volume= 0.100 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 581.07' @ 12.09 hrs Surf.Area= 714 sf Storage= 880 cf

Plug-Flow detention time= 106.4 min calculated for 0.100 af (84% of inflow)
Center-of-Mass det. time= 40.2 min (828.1 - 787.9)

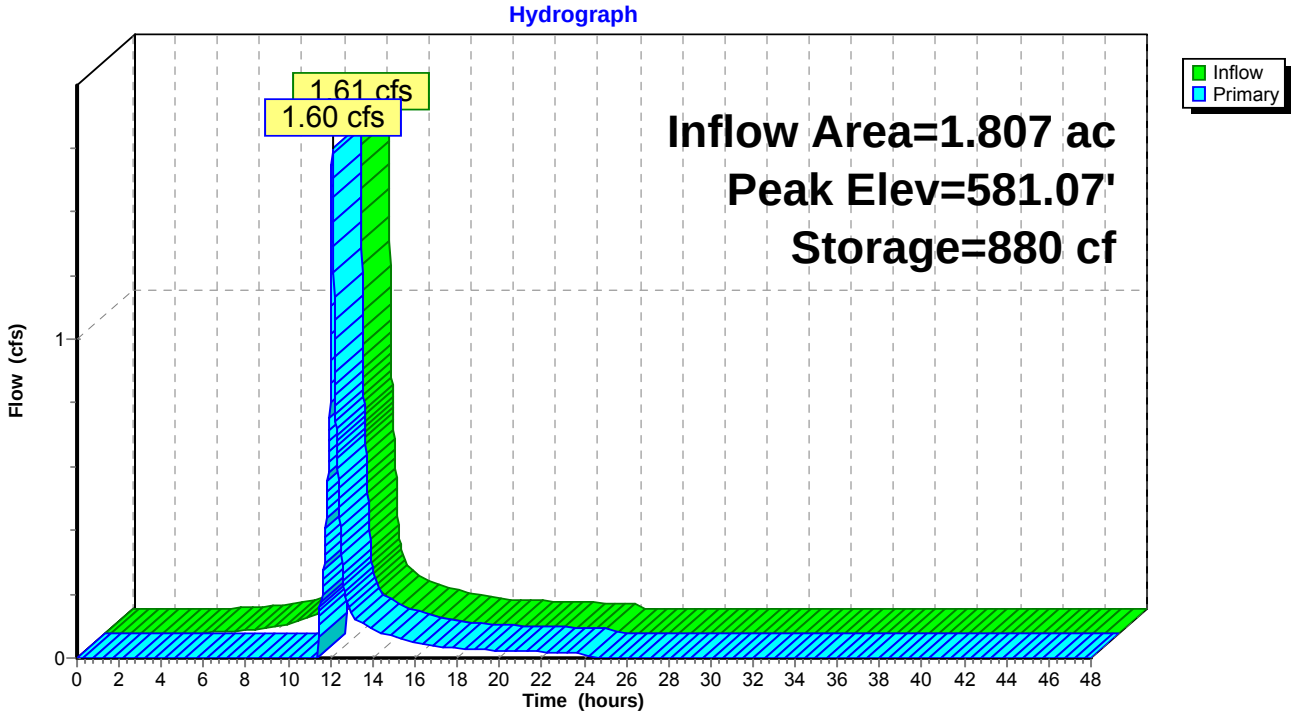
Volume	Invert	Avail.Storage	Storage Description
#1	579.00'	1,542 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
579.00	150	0	0
580.00	396	273	273
581.00	714	555	828
582.00	714	714	1,542

Device	Routing	Invert	Outlet Devices
#1	Primary	581.00'	**30.0' long x 1.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Primary OutFlow Max=1.59 cfs @ 12.09 hrs HW=581.07' (Free Discharge)
1=Broad-Crested Rectangular Weir (Weir Controls 1.59 cfs @ 0.73 fps)

Pond 3P: Forebay



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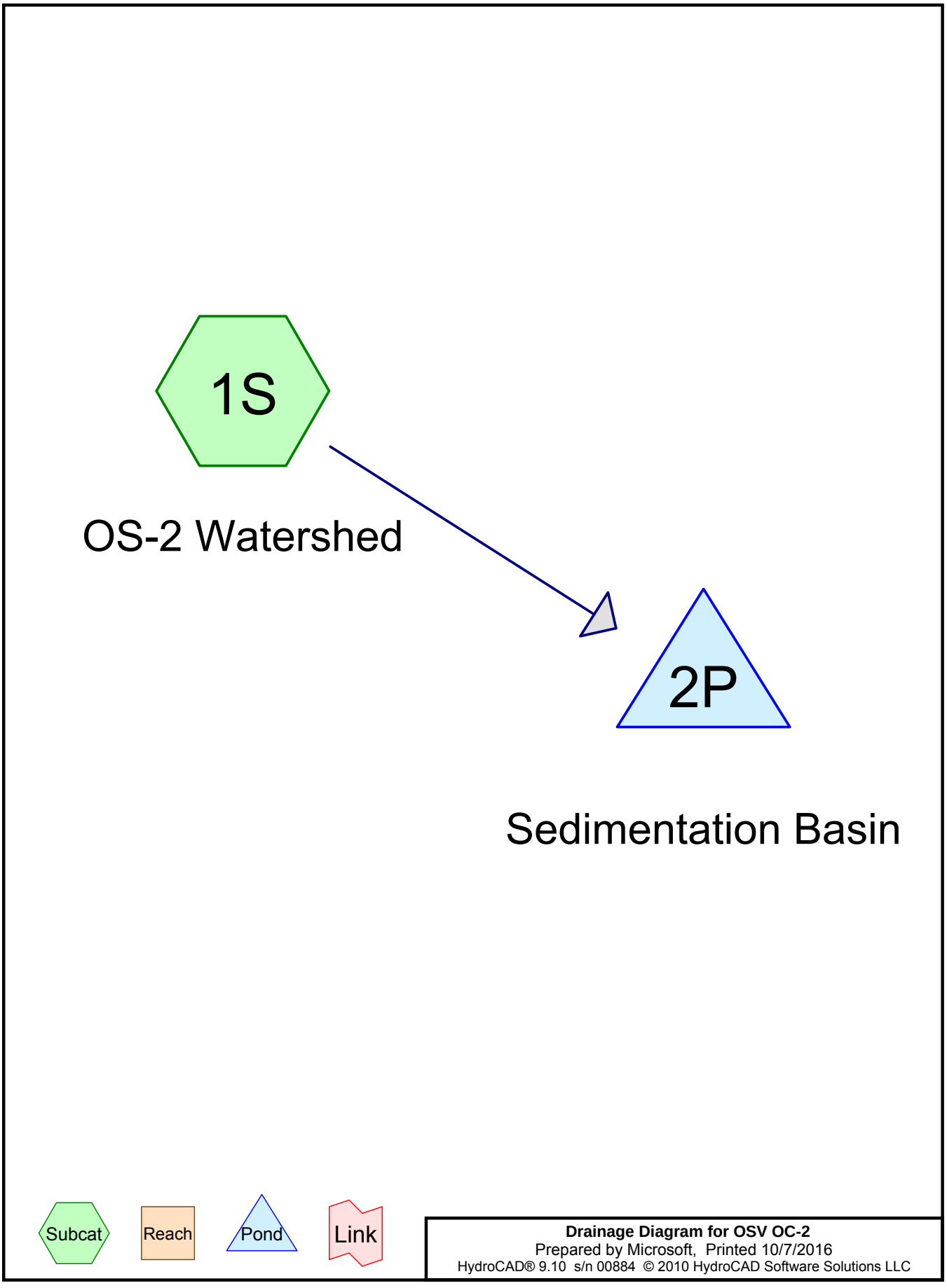
617-776-3350p 617-776-7710f

STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 2

DCI PROJECT: 2016-055



Drainage Diagram for OSV OC-2
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
3.000	98	Unconnected pavement, HSG A (1S)
3.000		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
3.000	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
3.000		**TOTAL AREA**

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: OS-2 Watershed Runoff Area=130,700 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=2.67 cfs 0.198 af

Pond 2P: Sedimentation Basin Peak Elev=99.01' Storage=764 cf Inflow=2.67 cfs 0.198 af
Discarded=0.04 cfs 0.053 af Primary=2.58 cfs 0.145 af Outflow=2.62 cfs 0.198 af

Total Runoff Area = 3.000 ac Runoff Volume = 0.198 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 3.000 ac

Summary for Subcatchment 1S: OS-2 Watershed

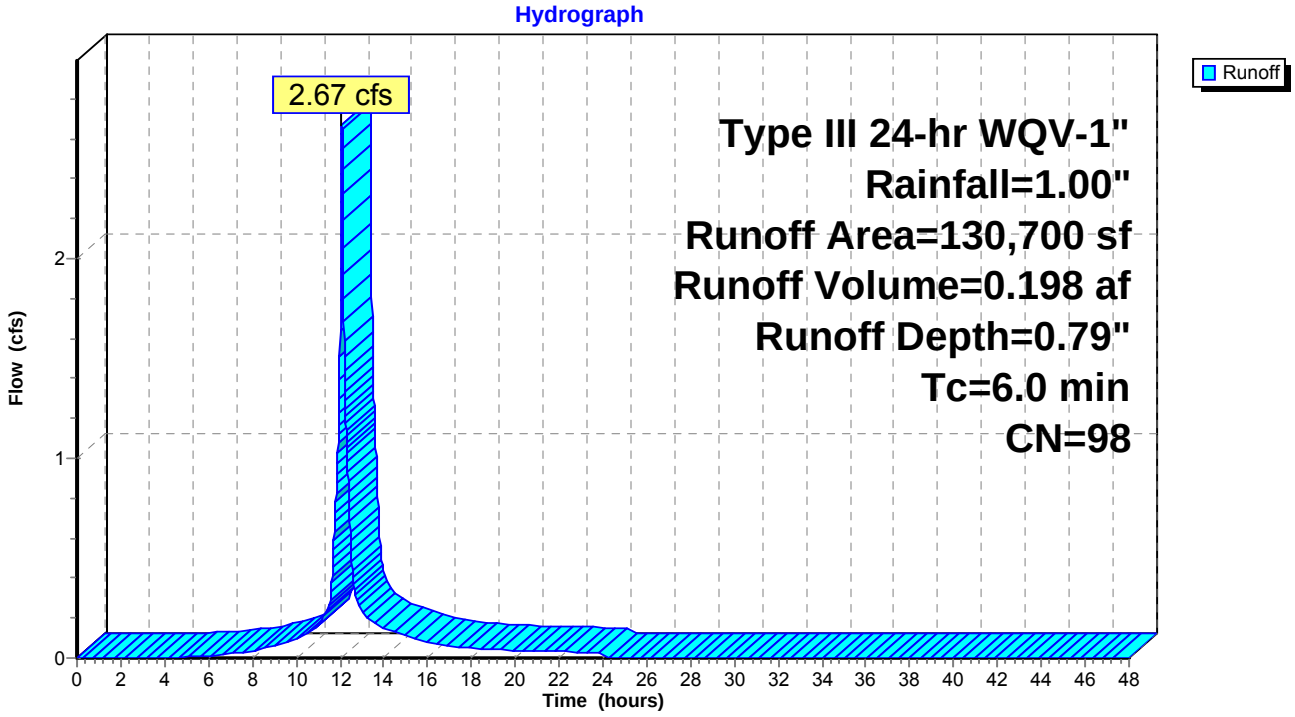
Runoff = 2.67 cfs @ 12.08 hrs, Volume= 0.198 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

Area (sf)	CN	Description
130,700	98	Unconnected pavement, HSG A
130,700		100.00% Impervious Area
130,700		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Subcatchment 1S: OS-2 Watershed



Summary for Pond 2P: Sedimentation Basin

Inflow Area = 3.000 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 2.67 cfs @ 12.08 hrs, Volume= 0.198 af
Outflow = 2.62 cfs @ 12.10 hrs, Volume= 0.198 af, Atten= 2%, Lag= 0.9 min
Discarded = 0.04 cfs @ 12.10 hrs, Volume= 0.053 af
Primary = 2.58 cfs @ 12.10 hrs, Volume= 0.145 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.01' @ 12.10 hrs Surf.Area= 534 sf Storage= 764 cf

Plug-Flow detention time= 75.9 min calculated for 0.198 af (100% of inflow)
Center-of-Mass det. time= 75.8 min (863.7 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	96.00'	1,426 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

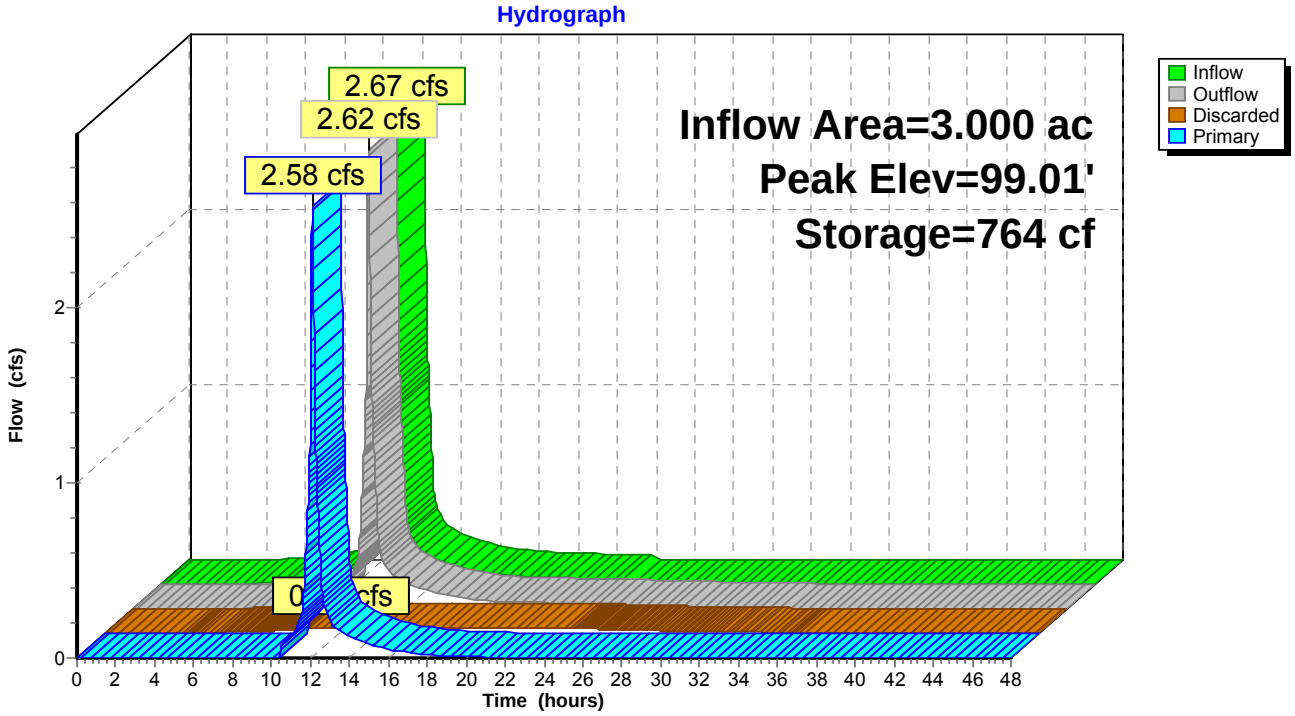
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
96.00	50	0	0
97.00	154	102	102
98.00	314	234	336
99.00	531	423	759
100.00	804	668	1,426

Device	Routing	Invert	Outlet Devices
#1	Primary	98.60'	**3.0' long Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	96.00'	**2.410 in/hr Exfiltration over Horizontal area above 95.00'** Conductivity to Groundwater Elevation = 91.00' Excluded Horizontal area = 0 sf Phase-In= 0.01'

Discarded OutFlow Max=0.04 cfs @ 12.10 hrs HW=99.01' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.04 cfs)

Primary OutFlow Max=2.58 cfs @ 12.10 hrs HW=99.01' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Weir Controls 2.58 cfs @ 2.10 fps)

Pond 2P: Sedimentation Basin



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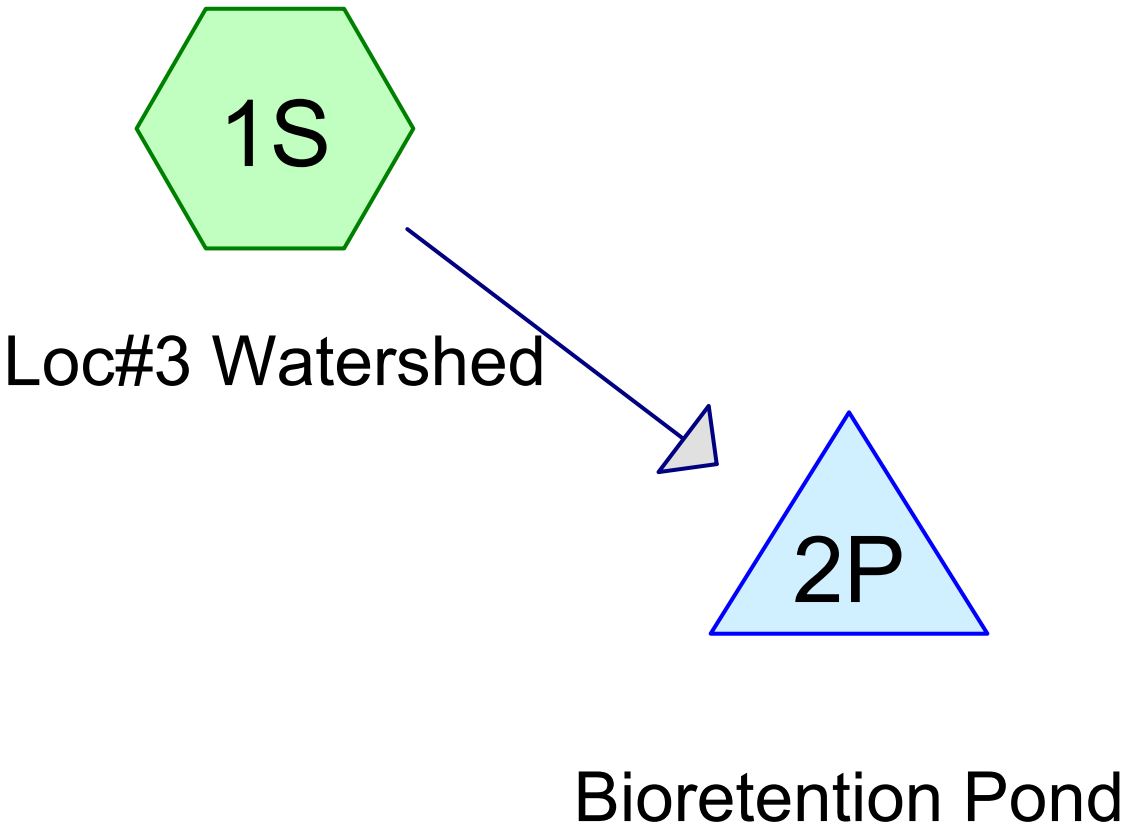
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 3

DCI PROJECT: 2016-055



Subcat Reach Pond Link

Drainage Diagram for OSV LOC-3
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.248	98	Paved parking, HSG A (1S)
0.248		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.248	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.248		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.248	Pavement	1S
0.248	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.248	Pavement	100.00	0.950	0.95
0.248	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#3 Watershed Runoff Area=10,800 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.22 cfs 0.016 af

Pond 2P: Bioretention Pond Peak Elev=99.24' Storage=183 cf Inflow=0.22 cfs 0.016 af
Discarded=0.04 cfs 0.016 af Primary=0.00 cfs 0.000 af Outflow=0.04 cfs 0.016 af

Total Runoff Area = 0.248 ac Runoff Volume = 0.016 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.248 ac

Summary for Subcatchment 1S: Loc#3 Watershed

Runoff = 0.22 cfs @ 12.08 hrs, Volume= 0.016 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

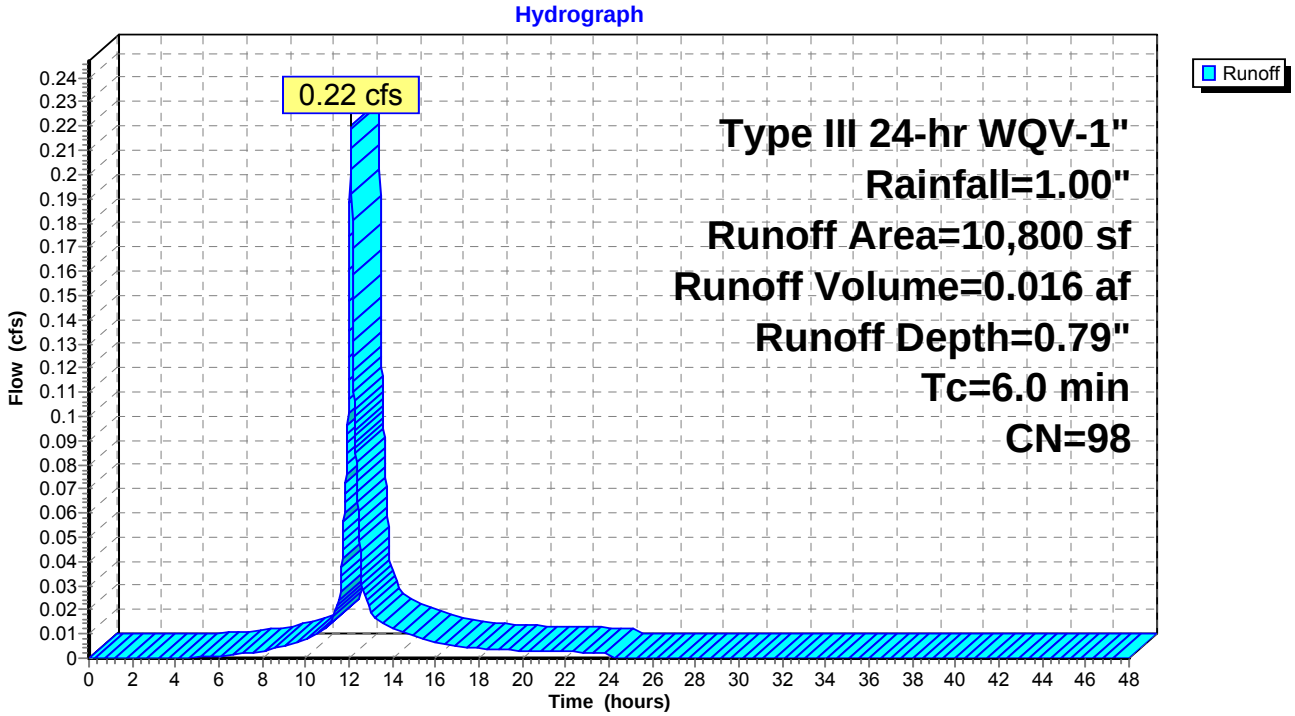
Area (sf)	CN	Description	Land Use
10,800	98	Paved parking, HSG A	Pavement
10,800		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
10,800	Pavement
10,800	Total

Subcatchment 1S: Loc#3 Watershed



Summary for Pond 2P: Bioretention Pond

Inflow Area = 0.248 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.22 cfs @ 12.08 hrs, Volume= 0.016 af
Outflow = 0.04 cfs @ 12.51 hrs, Volume= 0.016 af, Atten= 80%, Lag= 25.6 min
Discarded = 0.04 cfs @ 12.51 hrs, Volume= 0.016 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.24' @ 12.51 hrs Surf.Area= 768 sf Storage= 183 cf

Plug-Flow detention time= 24.8 min calculated for 0.016 af (100% of inflow)
Center-of-Mass det. time= 24.8 min (812.7 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	768 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

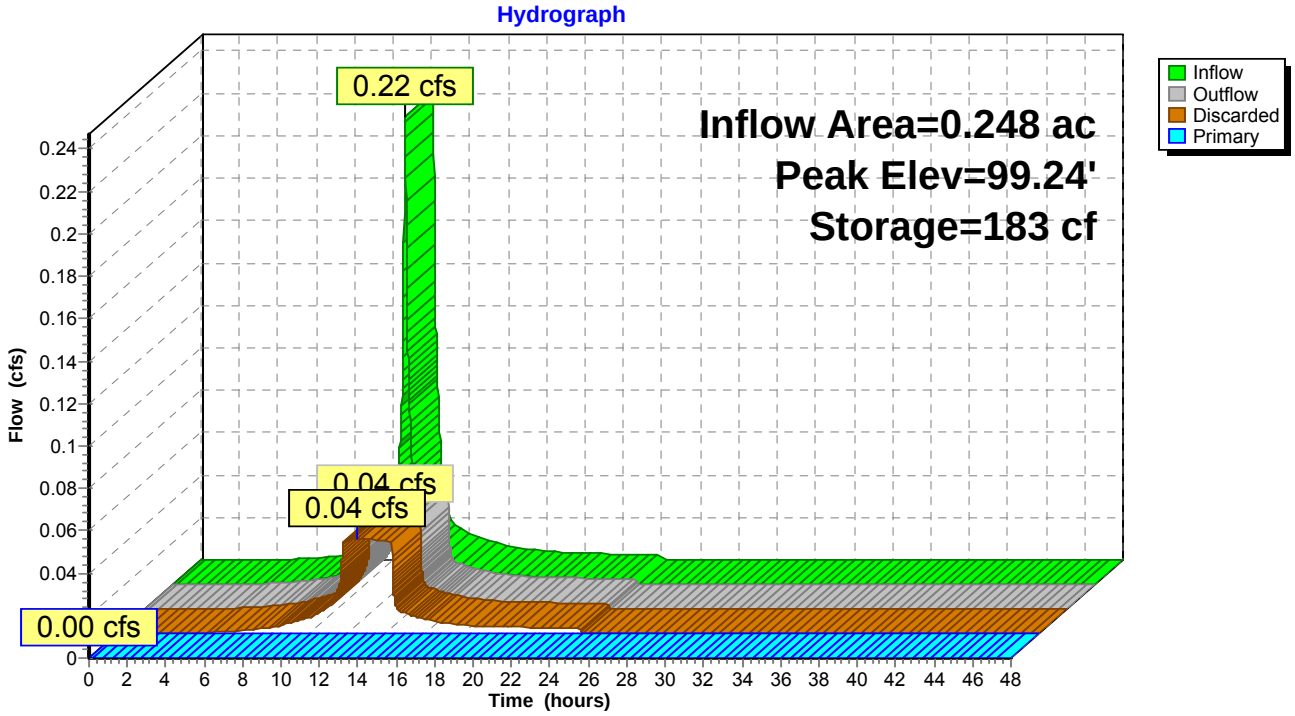
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	768	0	0
100.00	768	768	768

Device	Routing	Invert	Outlet Devices
#1	Primary	100.60'	**3.0' long Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	99.00'	**2.410 in/hr Exfiltration over Horizontal area above 98.00'** Conductivity to Groundwater Elevation = 94.00' Excluded Horizontal area = 0 sf Phase-In= 0.01'

Discarded OutFlow Max=0.04 cfs @ 12.51 hrs HW=99.24' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.04 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=99.00' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Controls 0.00 cfs)

Pond 2P: Bioretention Pond



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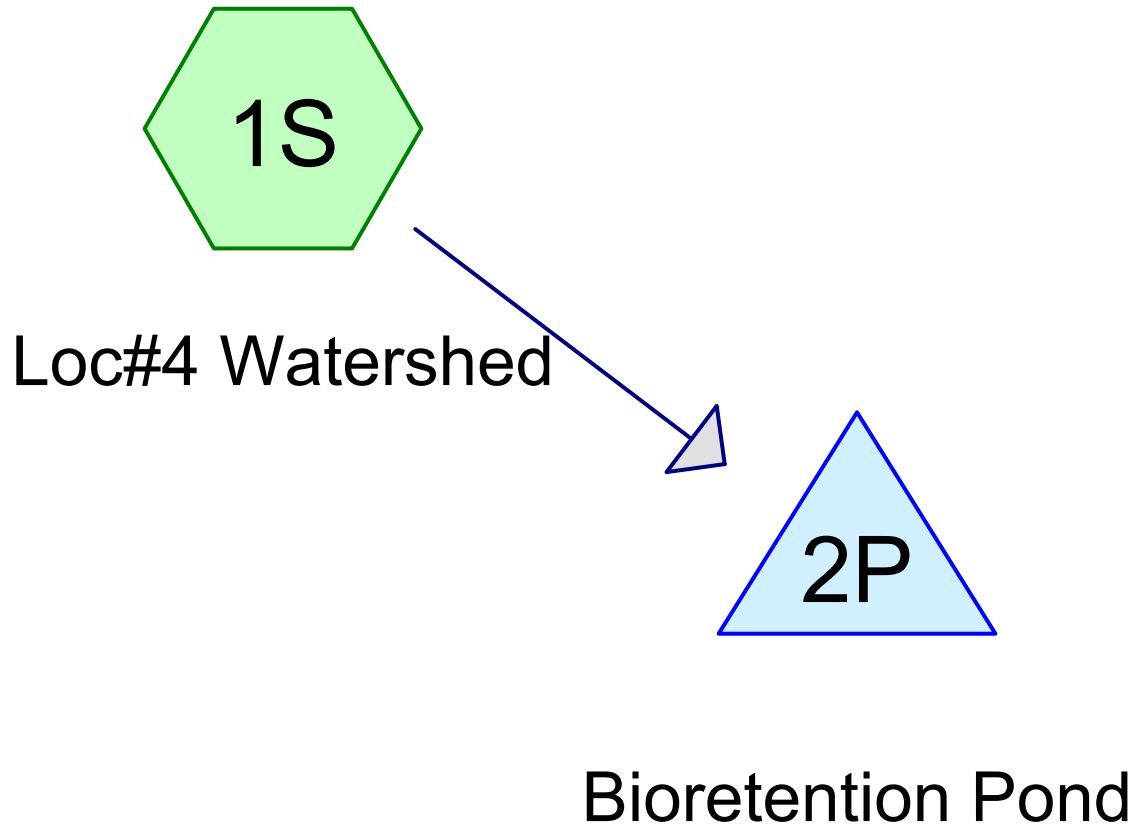
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 4

DCI PROJECT: 2016-055



Subcat Reach Pond Link

Drainage Diagram for OSV LOC-4
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.230	98	Paved parking, HSG A (1S)
0.230		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.230	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.230		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.230	Pavement	1S
0.230	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.230	Pavement	100.00	0.950	0.95
0.230	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#4 Watershed Runoff Area=10,000 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.20 cfs 0.015 af

Pond 2P: Bioretention Pond Peak Elev=99.31' Storage=187 cf Inflow=0.20 cfs 0.015 af
Discarded=0.04 cfs 0.015 af Primary=0.00 cfs 0.000 af Outflow=0.04 cfs 0.015 af

Total Runoff Area = 0.230 ac Runoff Volume = 0.015 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.230 ac

Summary for Subcatchment 1S: Loc#4 Watershed

Runoff = 0.20 cfs @ 12.08 hrs, Volume= 0.015 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

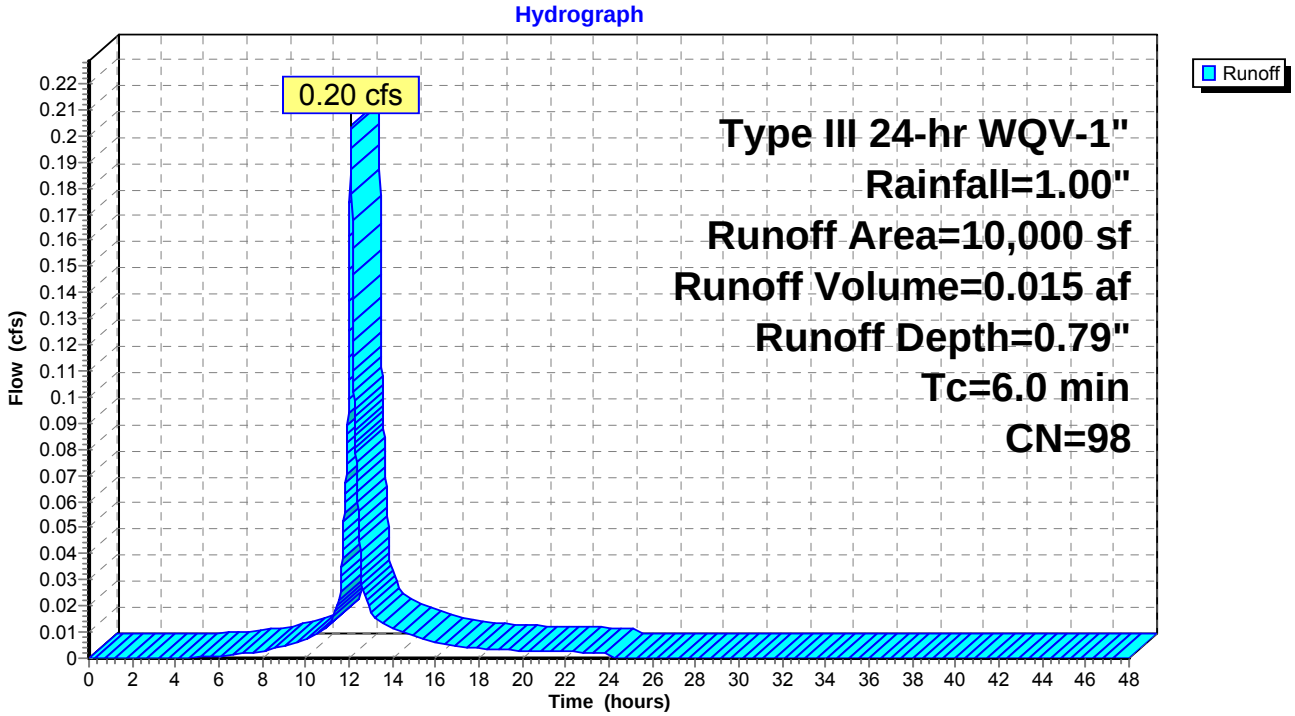
Area (sf)	CN	Description	Land Use
10,000	98	Paved parking, HSG A	Pavement
10,000		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
10,000	Pavement
10,000	Total

Subcatchment 1S: Loc#4 Watershed



Summary for Pond 2P: Bioretention Pond

Inflow Area = 0.230 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.20 cfs @ 12.08 hrs, Volume= 0.015 af
Outflow = 0.04 cfs @ 12.54 hrs, Volume= 0.015 af, Atten= 83%, Lag= 27.5 min
Discarded = 0.04 cfs @ 12.54 hrs, Volume= 0.015 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.31' @ 12.54 hrs Surf.Area= 600 sf Storage= 187 cf

Plug-Flow detention time= 33.3 min calculated for 0.015 af (100% of inflow)
Center-of-Mass det. time= 33.3 min (821.2 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	600 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

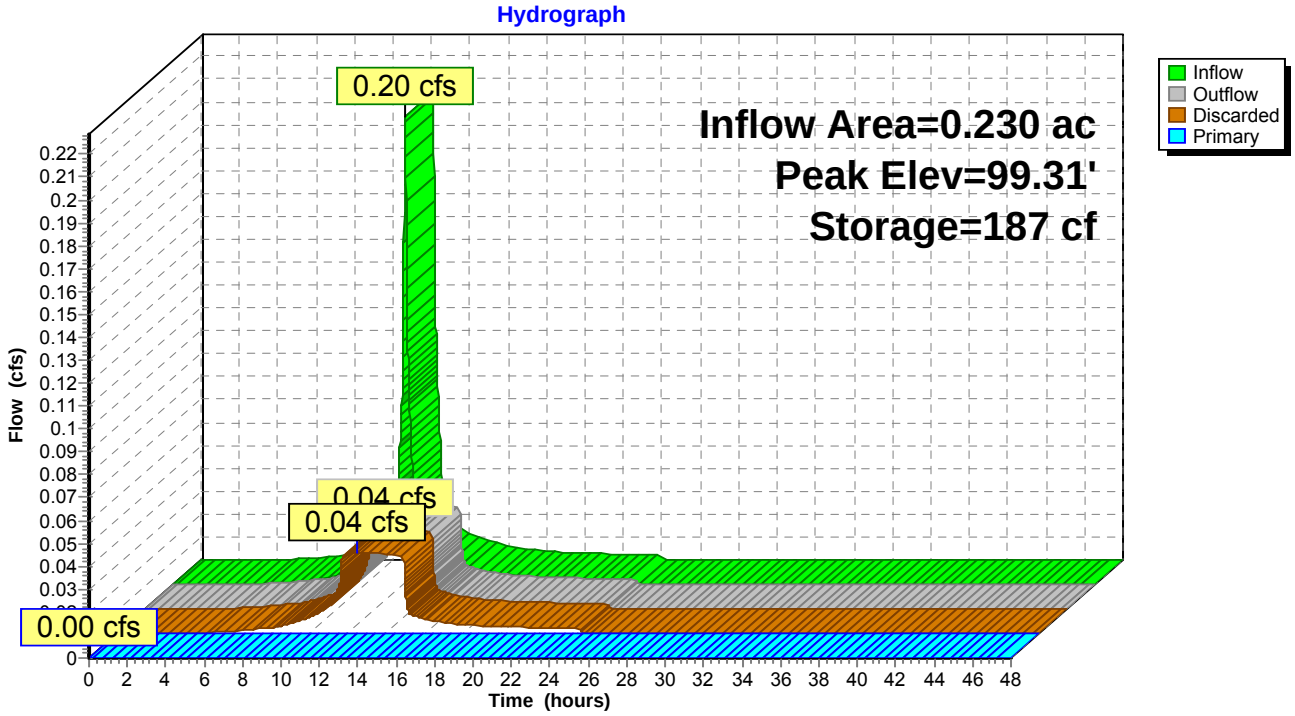
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	600	0	0
100.00	600	600	600

Device	Routing	Invert	Outlet Devices
#1	Primary	100.60'	**3.0' long Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	99.00'	**2.410 in/hr Exfiltration over Horizontal area above 98.00'** Conductivity to Groundwater Elevation = 94.00' Excluded Horizontal area = 0 sf Phase-In= 0.01'

Discarded OutFlow Max=0.04 cfs @ 12.54 hrs HW=99.31' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.04 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=99.00' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Controls 0.00 cfs)

Pond 2P: Bioretention Pond



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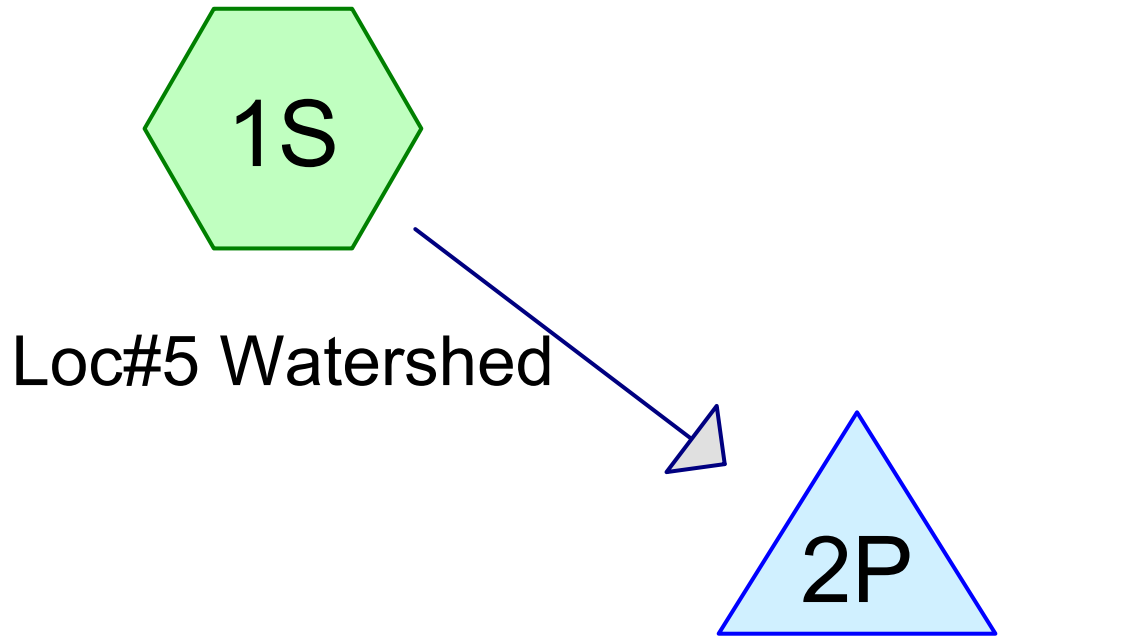
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 5

DCI PROJECT: 2016-055



Subcat Reach Pond Link

Drainage Diagram for OSV LOC-5
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.390	98	Paved parking, HSG A (1S)
0.390		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.390	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.390		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.390	Pavement	1S
0.390	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.390	Pavement	100.00	0.950	0.95
0.390	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#5 Watershed Runoff Area=17,000 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.35 cfs 0.026 af

Pond 2P: Bioretention Pond Peak Elev=100.73' Storage=300 cf Inflow=0.35 cfs 0.026 af
Discarded=0.02 cfs 0.021 af Primary=0.45 cfs 0.005 af Outflow=0.47 cfs 0.026 af

Total Runoff Area = 0.390 ac Runoff Volume = 0.026 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.390 ac

Summary for Subcatchment 1S: Loc#5 Watershed

Runoff = 0.35 cfs @ 12.08 hrs, Volume= 0.026 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

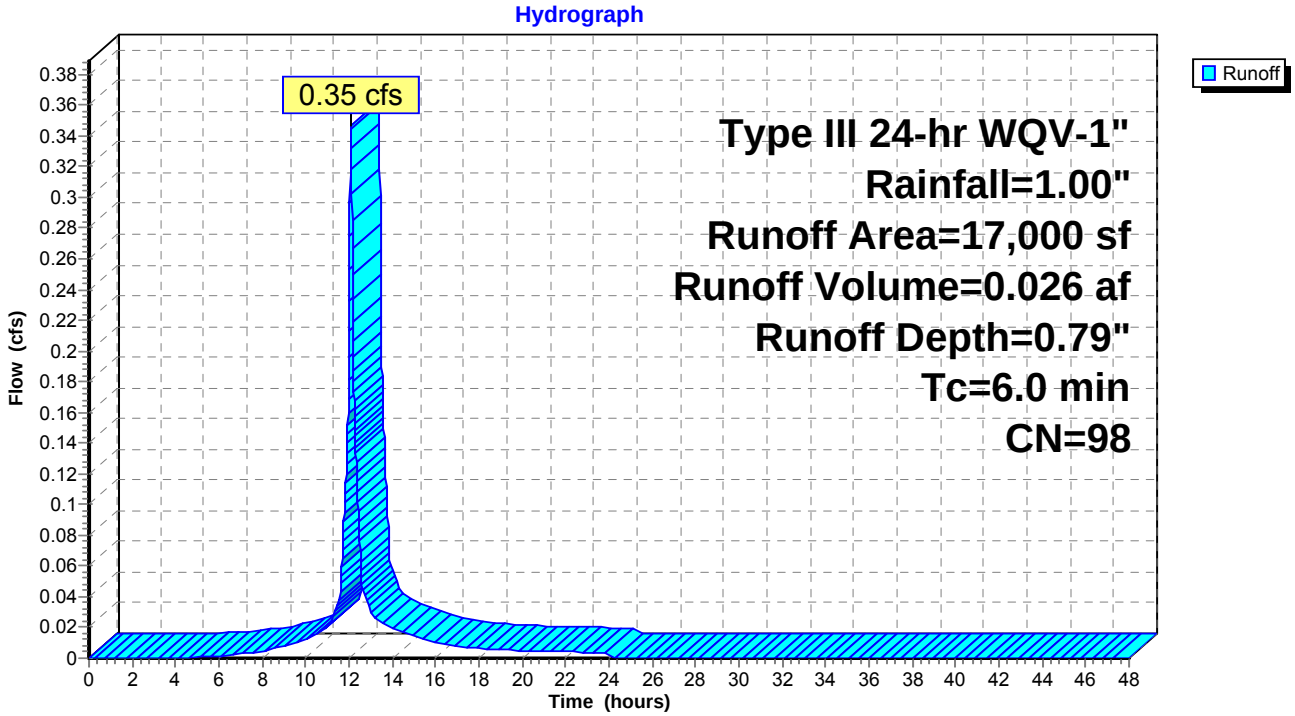
Area (sf)	CN	Description	Land Use
17,000	98	Paved parking, HSG A	Pavement
17,000		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
17,000	Pavement
17,000	Total

Subcatchment 1S: Loc#5 Watershed



Summary for Pond 2P: Bioretention Pond

[93] Warning: Storage range exceeded by 0.73'
[88] Warning: Qout>Qin may require Finer Routing>1
[85] Warning: Oscillations may require Finer Routing>1

Inflow Area = 0.390 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.35 cfs @ 12.08 hrs, Volume= 0.026 af
Outflow = 0.47 cfs @ 12.15 hrs, Volume= 0.026 af, Atten= 0%, Lag= 3.9 min
Discarded = 0.02 cfs @ 12.15 hrs, Volume= 0.021 af
Primary = 0.45 cfs @ 12.15 hrs, Volume= 0.005 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 100.73' @ 12.15 hrs Surf.Area= 300 sf Storage= 300 cf

Plug-Flow detention time= 108.3 min calculated for 0.026 af (100% of inflow)
Center-of-Mass det. time= 108.3 min (896.2 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	300 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

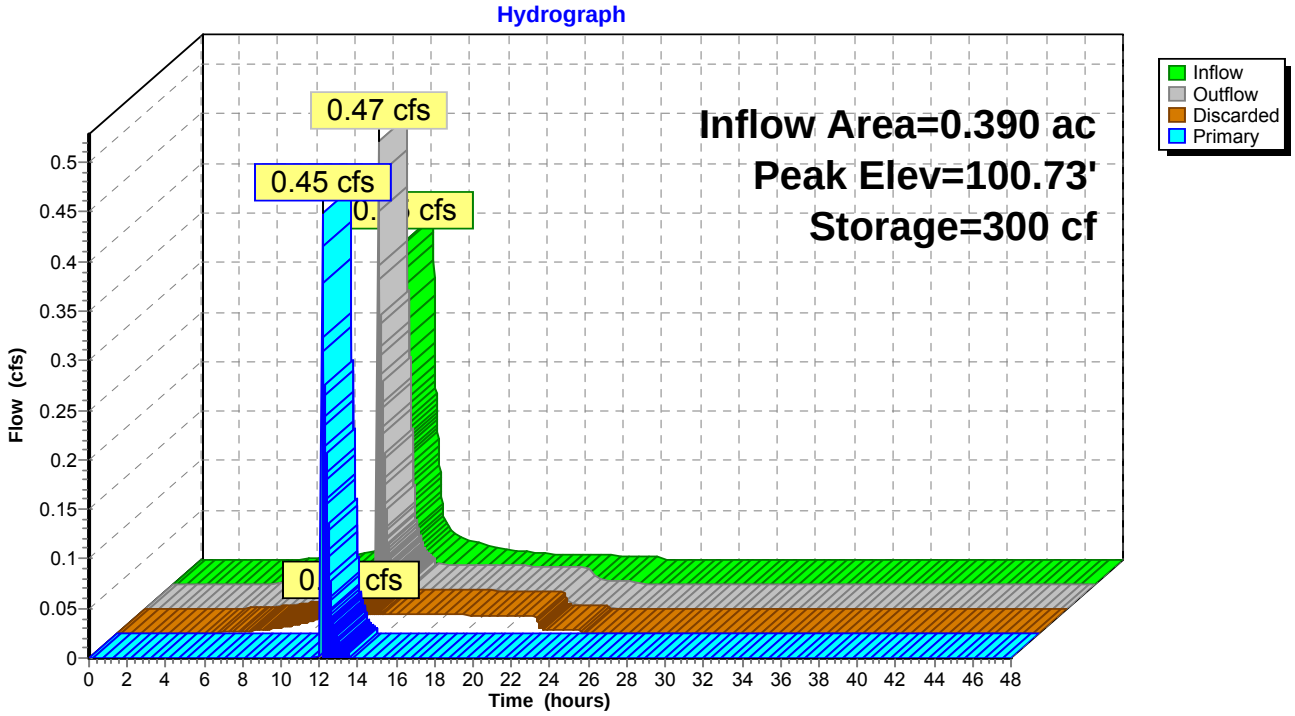
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	300	0	0
100.00	300	300	300

Device	Routing	Invert	Outlet Devices
#1	Primary	100.60'	**3.0' long Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	99.00'	**2.410 in/hr Exfiltration over Horizontal area above 98.00'** Conductivity to Groundwater Elevation = 94.00' Excluded Horizontal area = 0 sf Phase-In= 0.01'

Discarded OutFlow Max=0.02 cfs @ 12.15 hrs HW=100.73' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.02 cfs)

Primary OutFlow Max=0.44 cfs @ 12.15 hrs HW=100.73' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Weir Controls 0.44 cfs @ 1.16 fps)

Pond 2P: Bioretention Pond



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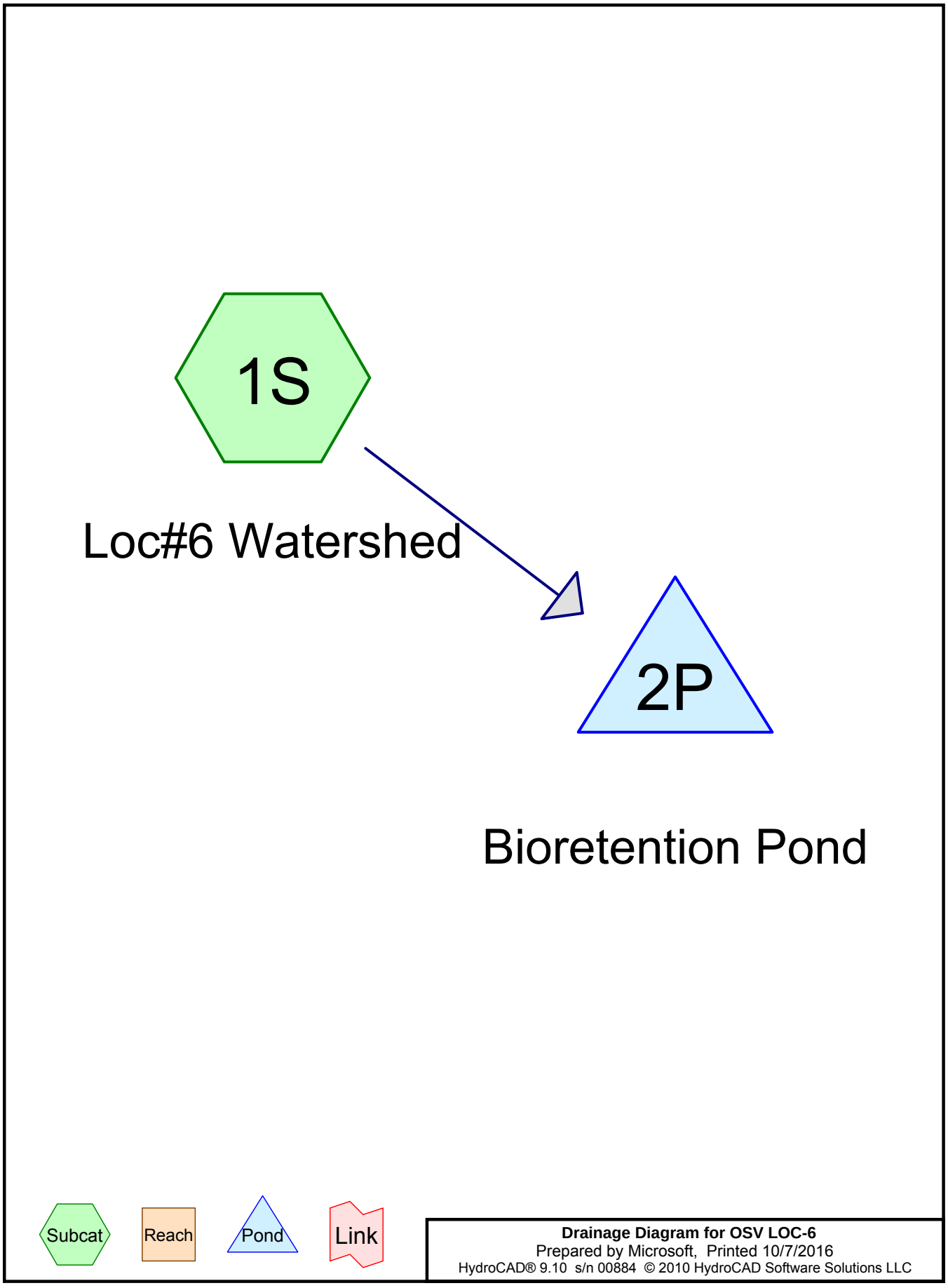
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 6

DCI PROJECT: 2016-055



Drainage Diagram for OSV LOC-6
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.354	98	Paved parking, HSG A (1S)
0.354		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.354	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.354		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.354	Pavement	1S
0.354	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.354	Pavement	100.00	0.950	0.95
0.354	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#6 Watershed Runoff Area=15,400 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.31 cfs 0.023 af

Pond 2P: Bioretention Pond Peak Elev=572.07' Storage=373 cf Inflow=0.31 cfs 0.023 af
Discarded=0.02 cfs 0.020 af Primary=0.12 cfs 0.003 af Outflow=0.15 cfs 0.023 af

Total Runoff Area = 0.354 ac Runoff Volume = 0.023 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.354 ac

Summary for Subcatchment 1S: Loc#6 Watershed

Runoff = 0.31 cfs @ 12.08 hrs, Volume= 0.023 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

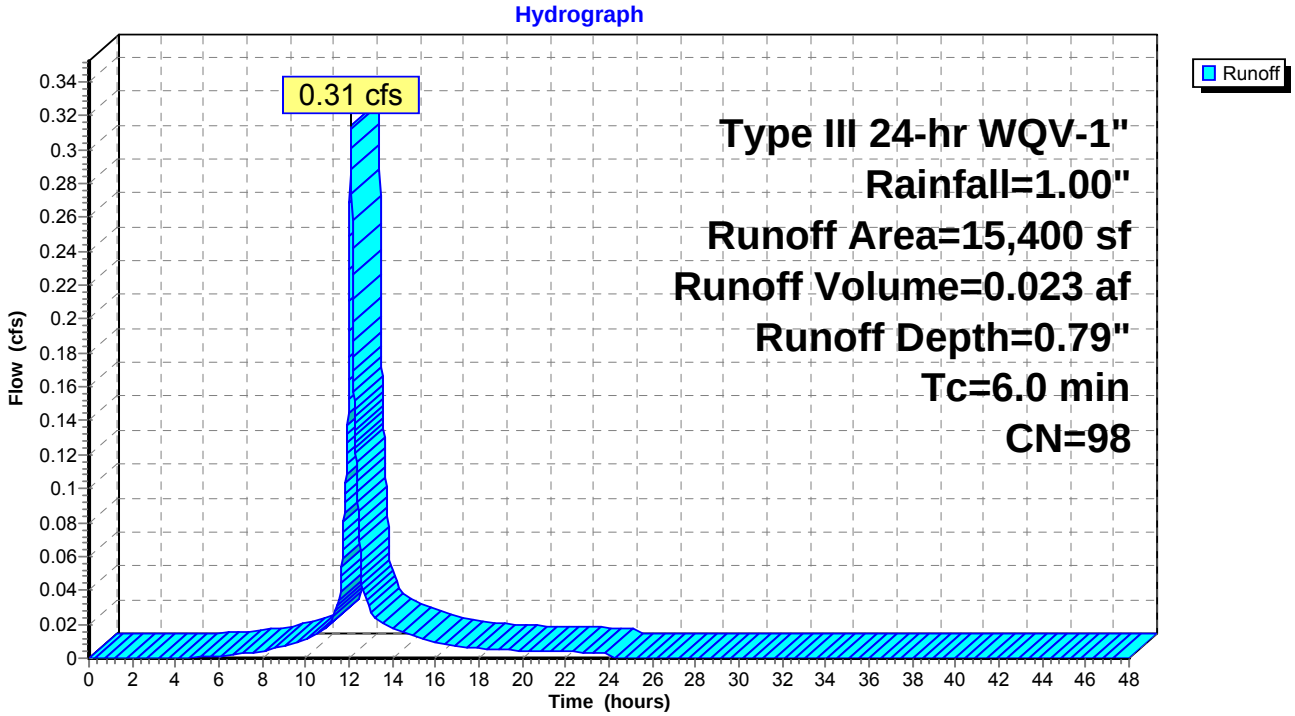
Area (sf)	CN	Description	Land Use
15,400	98	Paved parking, HSG A	Pavement
15,400		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
15,400	Pavement
15,400	Total

Subcatchment 1S: Loc#6 Watershed



Summary for Pond 2P: Bioretention Pond

Inflow Area = 0.354 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.31 cfs @ 12.08 hrs, Volume= 0.023 af
Outflow = 0.15 cfs @ 12.25 hrs, Volume= 0.023 af, Atten= 53%, Lag= 9.8 min
Discarded = 0.02 cfs @ 12.25 hrs, Volume= 0.020 af
Primary = 0.12 cfs @ 12.25 hrs, Volume= 0.003 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 572.07' @ 12.25 hrs Surf.Area= 360 sf Storage= 373 cf

Plug-Flow detention time= 161.6 min calculated for 0.023 af (100% of inflow)
Center-of-Mass det. time= 161.6 min (949.5 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	570.00'	564 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

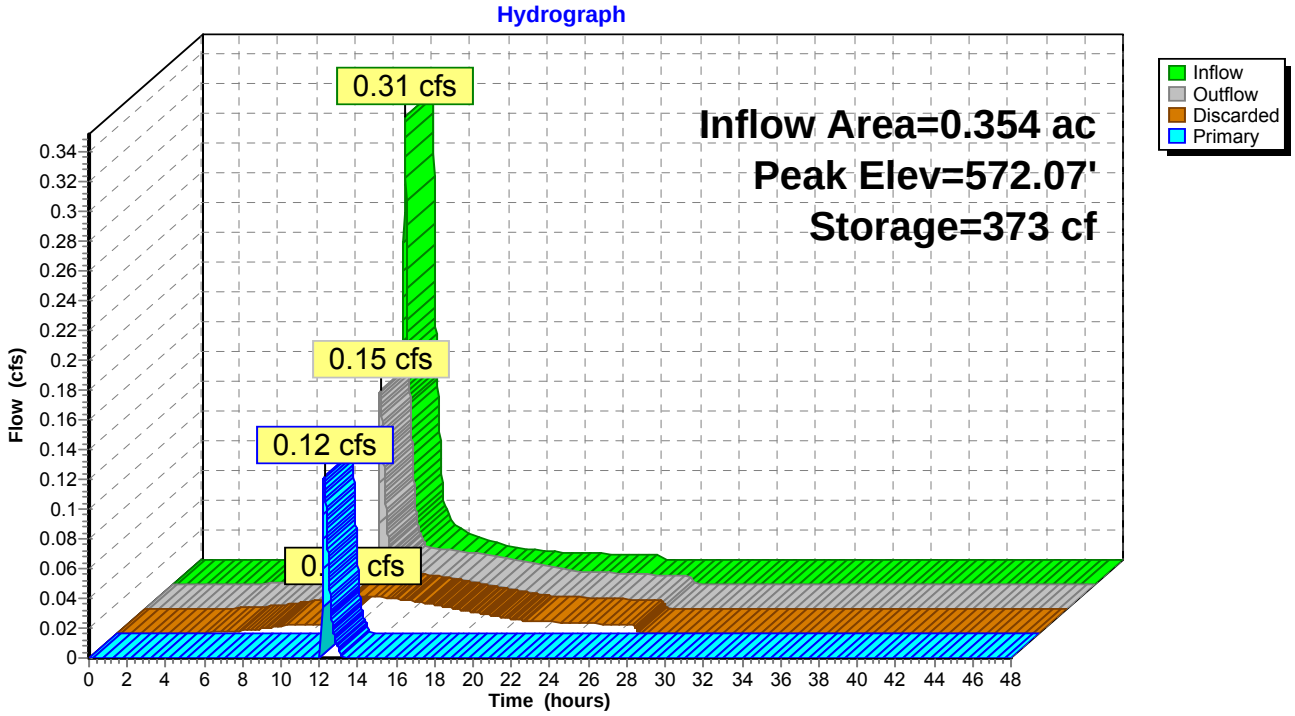
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
570.00	96	0	0
571.00	120	108	108
572.00	360	240	348
572.60	360	216	564

Device	Routing	Invert	Outlet Devices
#1	Primary	572.00'	**2.0' long Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	570.00'	**2.410 in/hr Exfiltration over Horizontal area above 569.00'** Conductivity to Groundwater Elevation = 566.00' Excluded Horizontal area = 0 sf Phase-In= 0.01'

Discarded OutFlow Max=0.02 cfs @ 12.25 hrs HW=572.07' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.02 cfs)

Primary OutFlow Max=0.12 cfs @ 12.25 hrs HW=572.07' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Weir Controls 0.12 cfs @ 0.87 fps)

Pond 2P: Bioretention Pond



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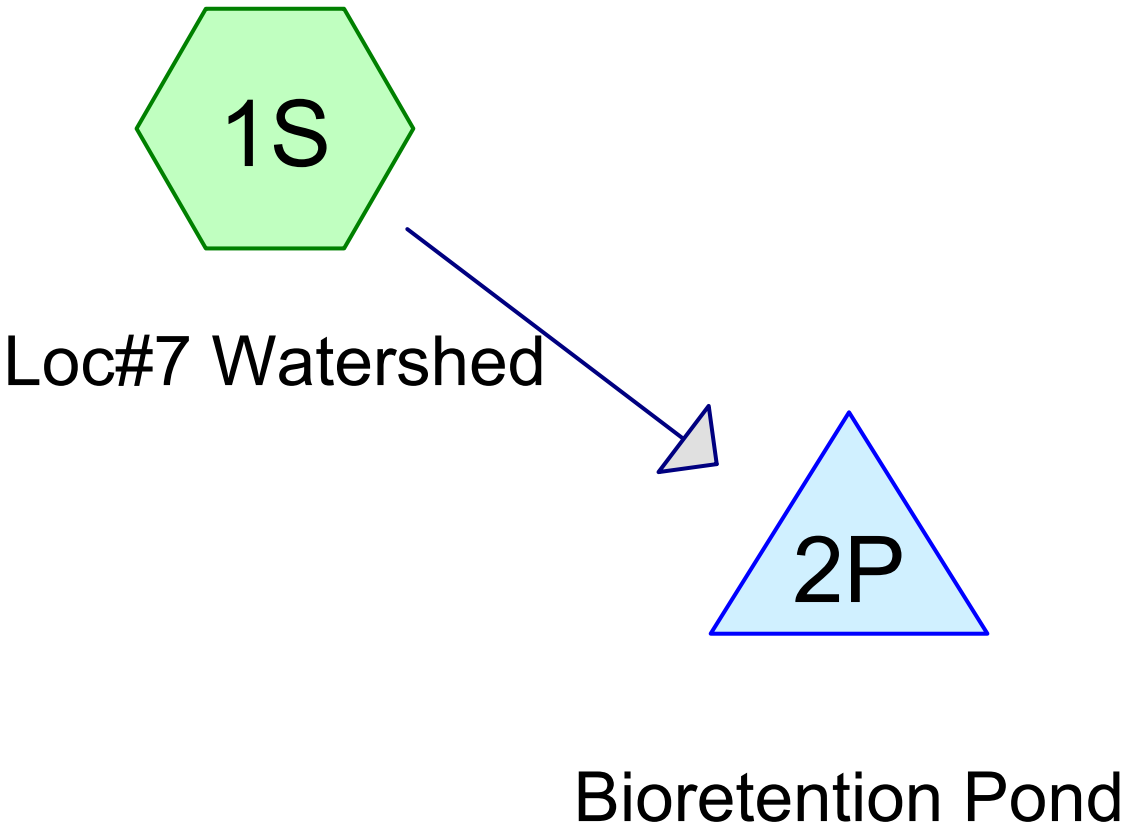
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 7

DCI PROJECT: 2016-055



Subcat Reach Pond Link

Drainage Diagram for OSV LOC-7
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.108	98	Paved parking, HSG A (1S)
0.108		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.108	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.108		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.108	Pavement	1S
0.108	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.108	Pavement	100.00	0.950	0.95
0.108	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#7 Watershed Runoff Area=4,700 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.10 cfs 0.007 af

Pond 2P: Bioretention Pond Peak Elev=99.15' Storage=128 cf Inflow=0.10 cfs 0.007 af
Discarded=0.01 cfs 0.007 af Primary=0.00 cfs 0.000 af Outflow=0.01 cfs 0.007 af

Total Runoff Area = 0.108 ac Runoff Volume = 0.007 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.108 ac

Summary for Subcatchment 1S: Loc#7 Watershed

Runoff = 0.10 cfs @ 12.08 hrs, Volume= 0.007 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

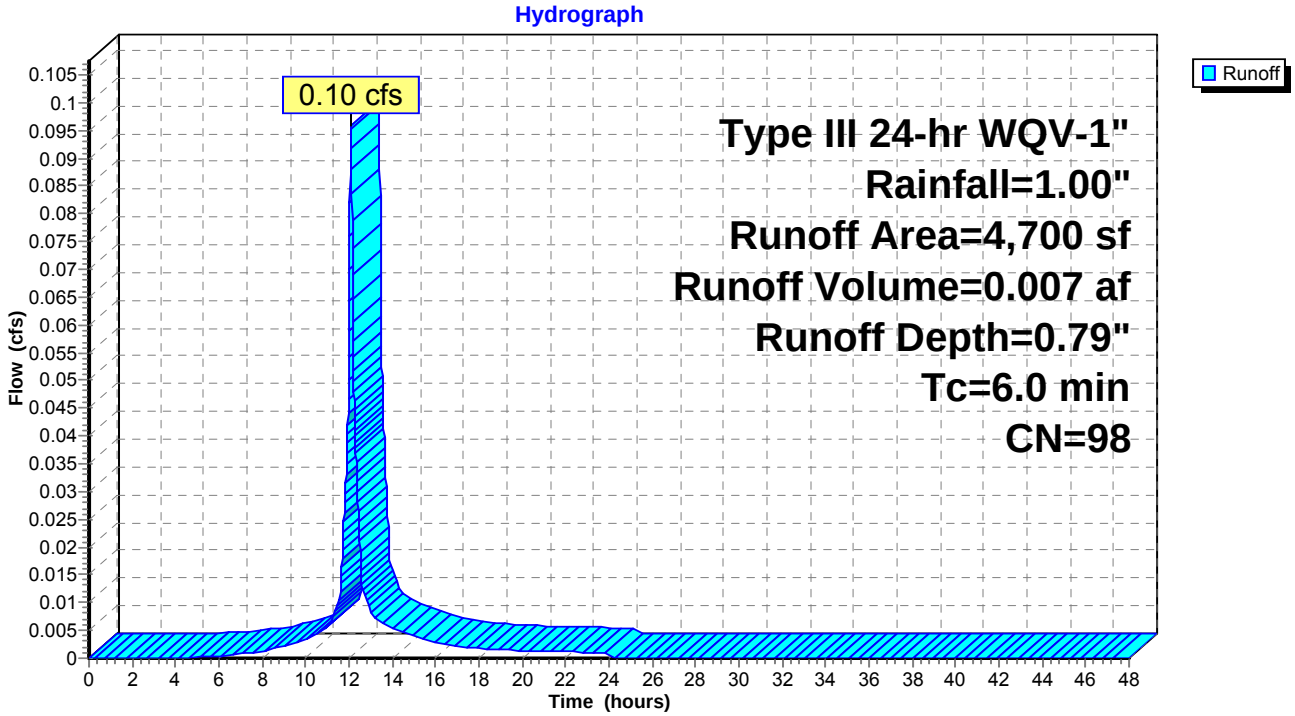
Area (sf)	CN	Description	Land Use
4,700	98	Paved parking, HSG A	Pavement
4,700		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
4,700	Pavement
4,700	Total

Subcatchment 1S: Loc#7 Watershed



Summary for Pond 2P: Bioretention Pond

Inflow Area = 0.108 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.10 cfs @ 12.08 hrs, Volume= 0.007 af
Outflow = 0.01 cfs @ 12.70 hrs, Volume= 0.007 af, Atten= 88%, Lag= 36.9 min
Discarded = 0.01 cfs @ 12.70 hrs, Volume= 0.007 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.15' @ 12.70 hrs Surf.Area= 179 sf Storage= 128 cf

Plug-Flow detention time= 117.8 min calculated for 0.007 af (100% of inflow)
Center-of-Mass det. time= 117.8 min (905.7 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	98.00'	336 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

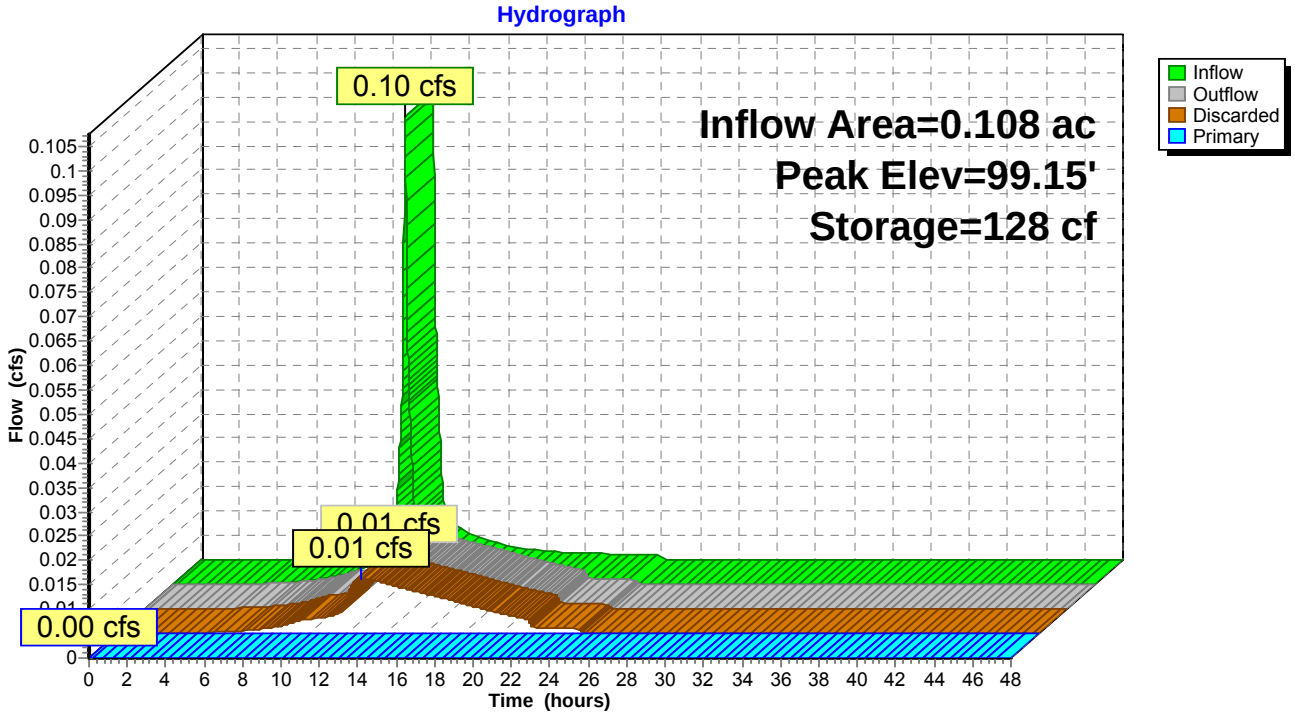
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
98.00	50	0	0
99.00	154	102	102
100.00	314	234	336

Device	Routing	Invert	Outlet Devices
#1	Primary	99.60'	**2.0' long Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	98.00'	**2.410 in/hr Exfiltration over Horizontal area above 97.00'** Conductivity to Groundwater Elevation = 93.00' Excluded Horizontal area = 0 sf Phase-In= 0.01'

Discarded OutFlow Max=0.01 cfs @ 12.70 hrs HW=99.15' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.01 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=98.00' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Controls 0.00 cfs)

Pond 2P: Bioretention Pond



SCALE: 1" = 40'

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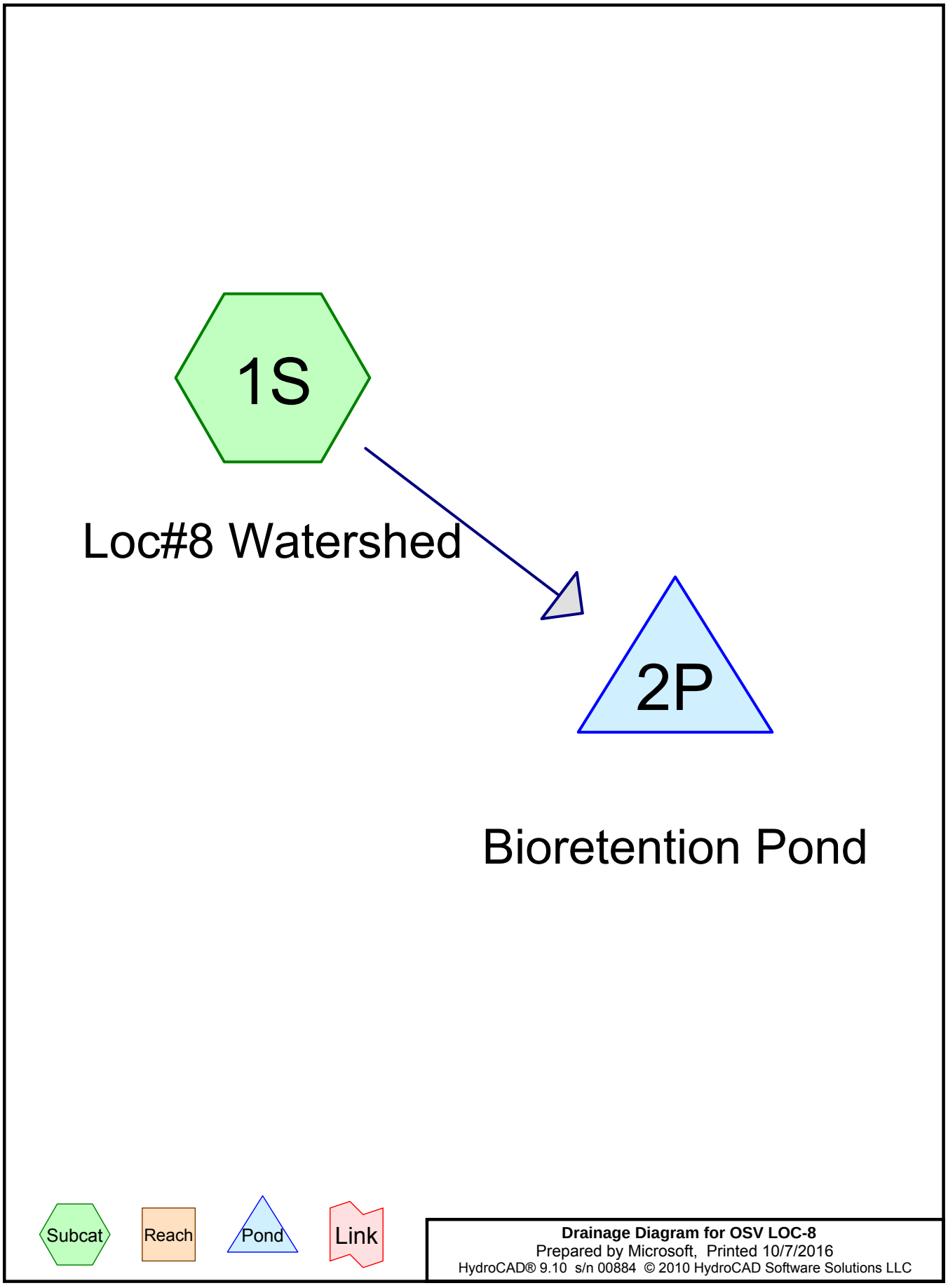
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 8

DCI PROJECT: 2016-055



Drainage Diagram for OSV LOC-8
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.126	98	Paved parking, HSG A (1S)
0.126		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.126	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.126		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.126	Pavement	1S
0.126	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.126	Pavement	100.00	0.950	0.95
0.126	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#8 Watershed Runoff Area=5,500 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.11 cfs 0.008 af

Pond 2P: Bioretention Pond Peak Elev=99.38' Storage=110 cf Inflow=0.11 cfs 0.008 af
Discarded=0.02 cfs 0.008 af Primary=0.00 cfs 0.000 af Outflow=0.02 cfs 0.008 af

Total Runoff Area = 0.126 ac Runoff Volume = 0.008 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.126 ac

Summary for Subcatchment 1S: Loc#8 Watershed

Runoff = 0.11 cfs @ 12.08 hrs, Volume= 0.008 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

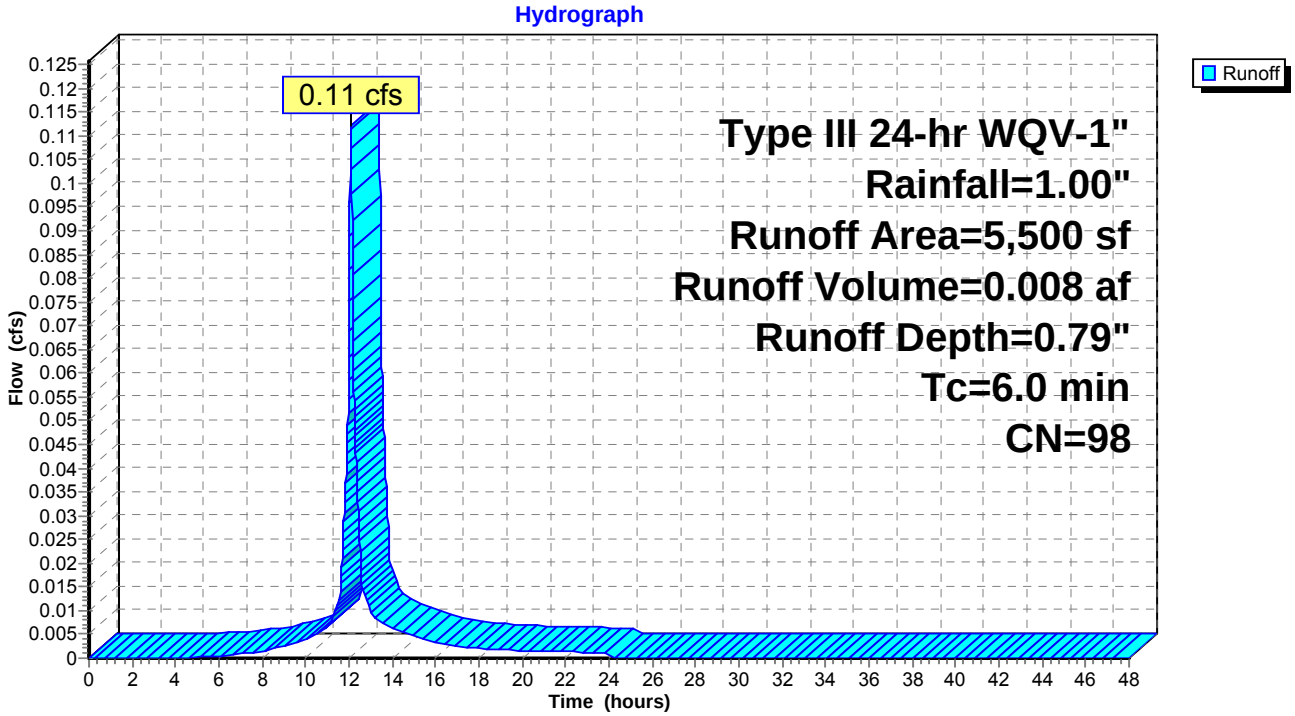
Area (sf)	CN	Description	Land Use
5,500	98	Paved parking, HSG A	Pavement
5,500		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
5,500	Pavement
5,500	Total

Subcatchment 1S: Loc#8 Watershed



Summary for Pond 2P: Bioretention Pond

Inflow Area = 0.126 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.11 cfs @ 12.08 hrs, Volume= 0.008 af
Outflow = 0.02 cfs @ 12.57 hrs, Volume= 0.008 af, Atten= 85%, Lag= 29.1 min
Discarded = 0.02 cfs @ 12.57 hrs, Volume= 0.008 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.38' @ 12.57 hrs Surf.Area= 288 sf Storage= 110 cf

Plug-Flow detention time= 42.0 min calculated for 0.008 af (100% of inflow)
Center-of-Mass det. time= 41.9 min (829.8 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	288 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

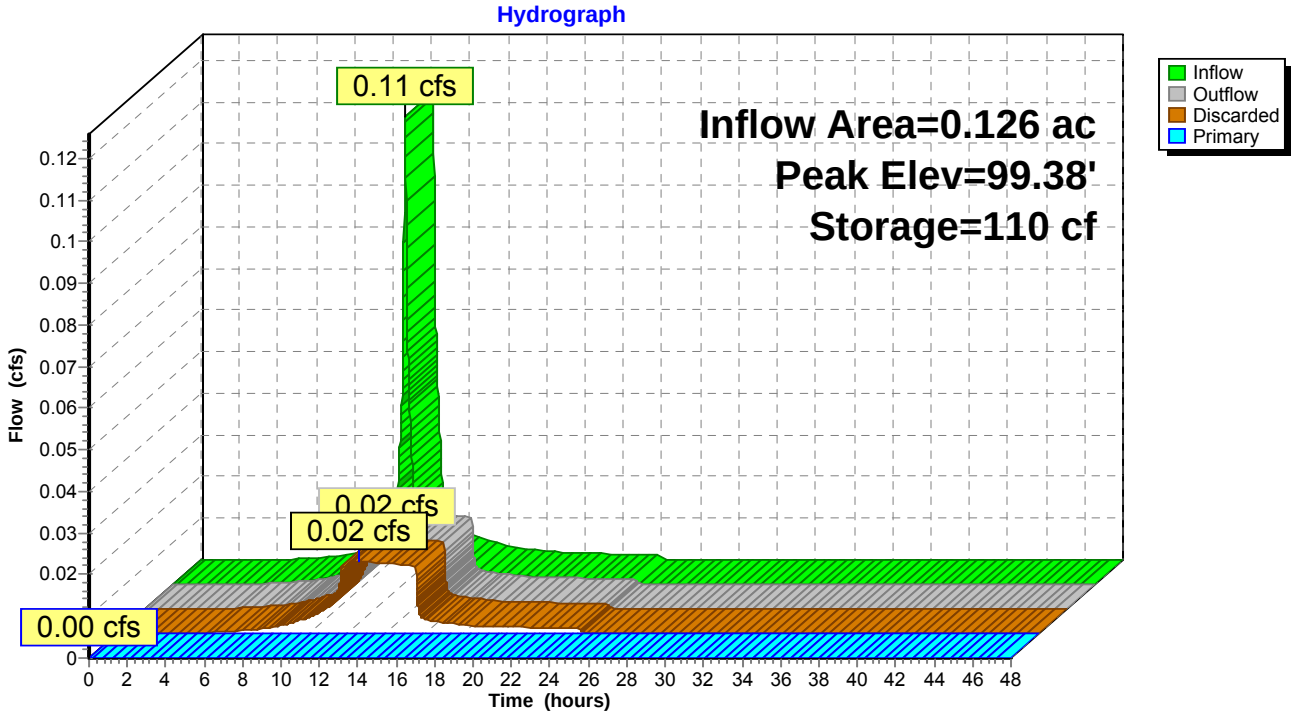
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	288	0	0
100.00	288	288	288

Device	Routing	Invert	Outlet Devices
#1	Primary	100.60'	**3.0' long Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	99.00'	**2.410 in/hr Exfiltration over Horizontal area above 98.00'** Conductivity to Groundwater Elevation = 94.00' Excluded Horizontal area = 0 sf Phase-In= 0.01'

Discarded OutFlow Max=0.02 cfs @ 12.57 hrs HW=99.38' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.02 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=99.00' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Controls 0.00 cfs)

Pond 2P: Bioretention Pond



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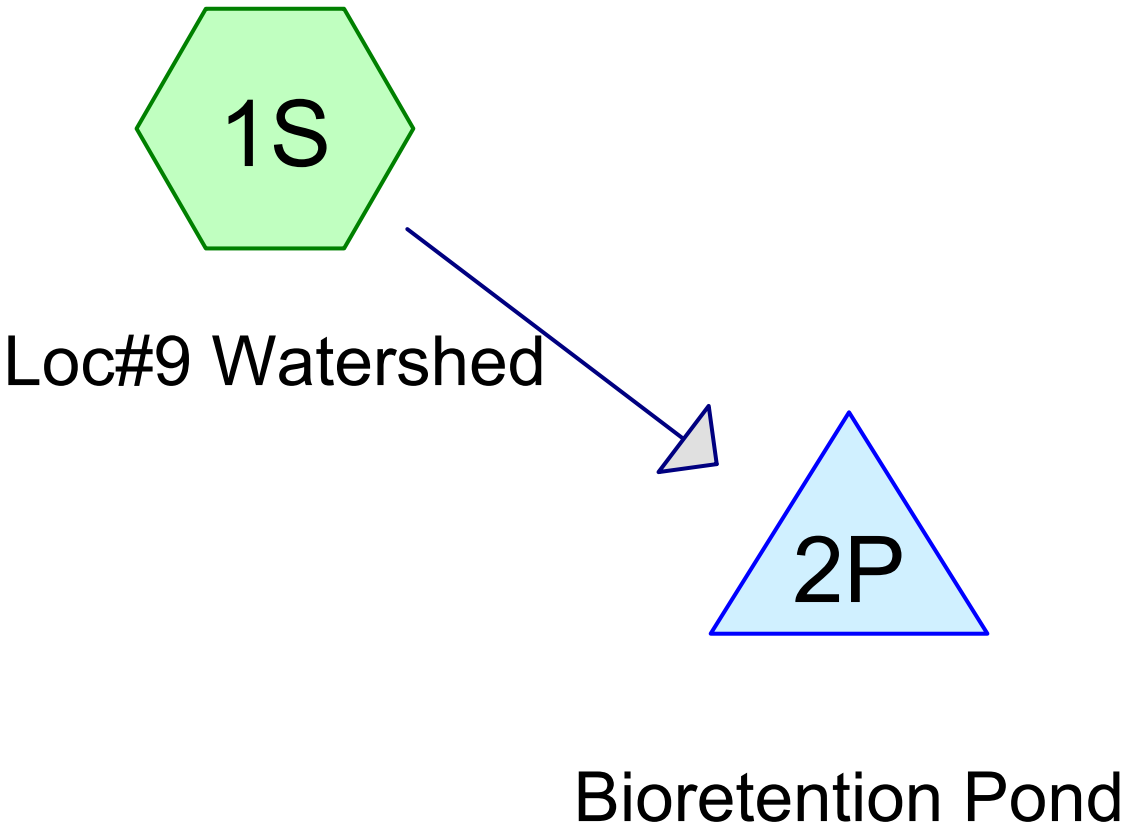
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 9

DCI PROJECT: 2016-055



Subcat Reach Pond Link

Drainage Diagram for OSV LOC-9
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.073	98	Paved parking, HSG A (1S)
0.073		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.073	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.073		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.073	Pavement	1S
0.073	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.073	Pavement	100.00	0.950	0.95
0.073	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#9 Watershed Runoff Area=3,200 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.07 cfs 0.005 af

Pond 2P: Bioretention Pond Peak Elev=99.78' Storage=78 cf Inflow=0.07 cfs 0.005 af
Discarded=0.01 cfs 0.005 af Primary=0.00 cfs 0.000 af Outflow=0.01 cfs 0.005 af

Total Runoff Area = 0.073 ac Runoff Volume = 0.005 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.073 ac

Summary for Subcatchment 1S: Loc#9 Watershed

Runoff = 0.07 cfs @ 12.08 hrs, Volume= 0.005 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

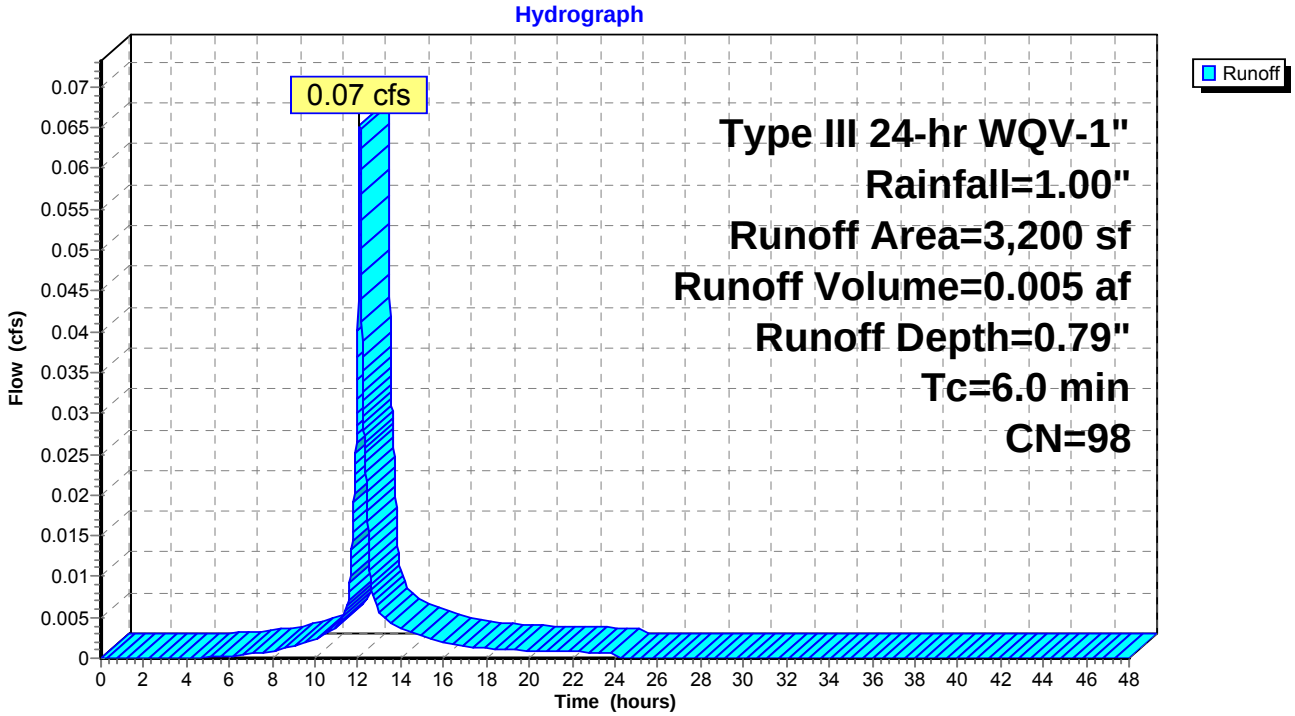
Area (sf)	CN	Description	Land Use
3,200	98	Paved parking, HSG A	Pavement
3,200		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
3,200	Pavement
3,200	Total

Subcatchment 1S: Loc#9 Watershed



Summary for Pond 2P: Bioretention Pond

Inflow Area = 0.073 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.07 cfs @ 12.08 hrs, Volume= 0.005 af
Outflow = 0.01 cfs @ 12.89 hrs, Volume= 0.005 af, Atten= 90%, Lag= 48.2 min
Discarded = 0.01 cfs @ 12.89 hrs, Volume= 0.005 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.78' @ 12.89 hrs Surf.Area= 100 sf Storage= 78 cf

Plug-Flow detention time= 95.1 min calculated for 0.005 af (100% of inflow)
Center-of-Mass det. time= 95.1 min (883.0 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	100 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

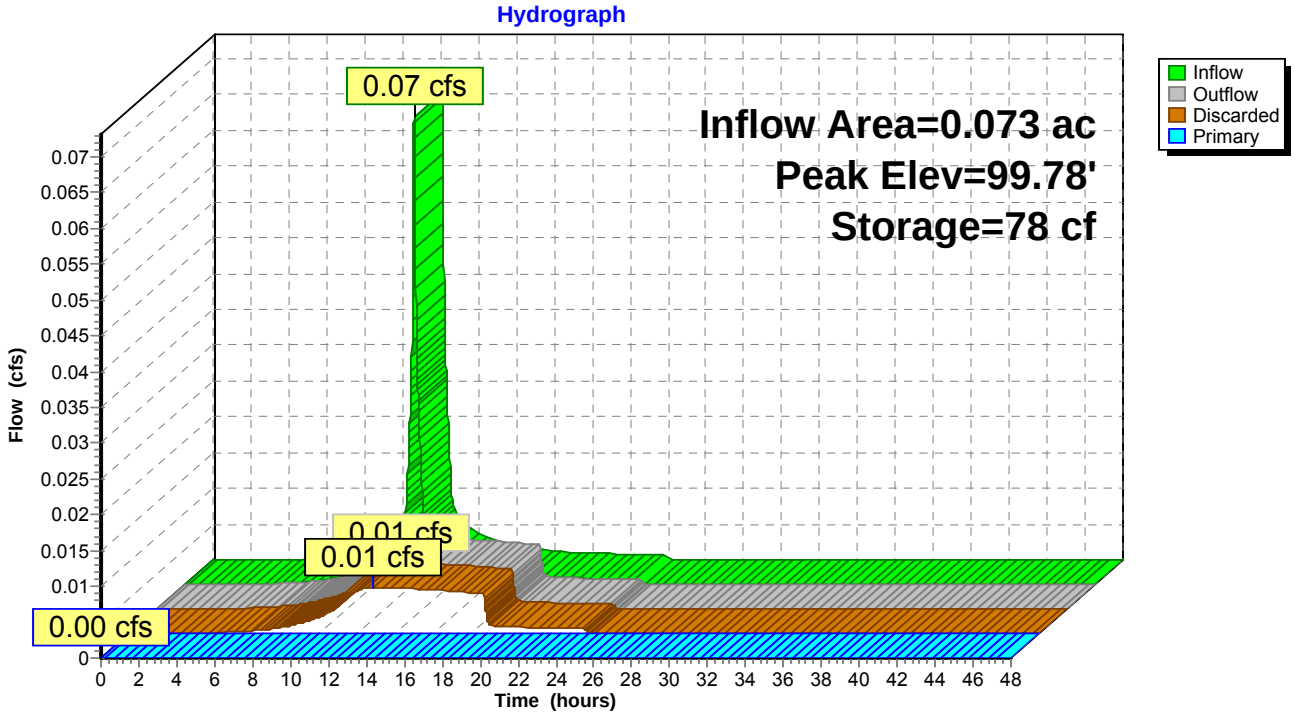
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	100	0	0
100.00	100	100	100

Device	Routing	Invert	Outlet Devices
#1	Primary	100.60'	**3.0' long Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	99.00'	**2.410 in/hr Exfiltration over Horizontal area above 98.00'** Conductivity to Groundwater Elevation = 94.00' Excluded Horizontal area = 0 sf Phase-In= 0.01'

Discarded OutFlow Max=0.01 cfs @ 12.89 hrs HW=99.78' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.01 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=99.00' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Controls 0.00 cfs)

Pond 2P: Bioretention Pond



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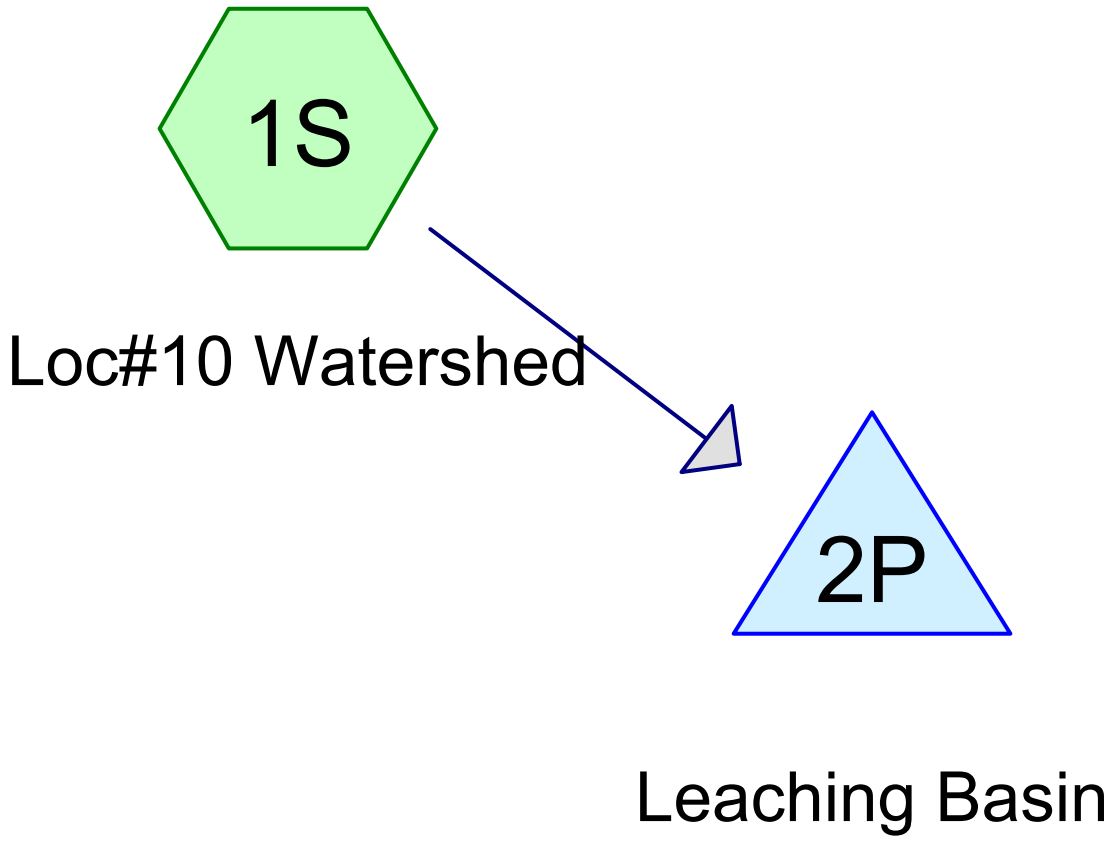
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 10

DCI PROJECT: 2016-055



Subcat Reach Pond Link

Drainage Diagram for OSV LOC-10
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.218	98	Paved parking, HSG A (1S)
0.218		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.218	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.218		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.218	Pavement	1S
0.218	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.218	Pavement	100.00	0.950	0.95
0.218	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#10 Watershed Runoff Area=9,500 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.19 cfs 0.014 af

Pond 2P: Leaching Basin Peak Elev=99.15' Storage=208 cf Inflow=0.19 cfs 0.014 af
Discarded=0.00 cfs 0.000 af Primary=0.19 cfs 0.010 af Outflow=0.19 cfs 0.010 af

Total Runoff Area = 0.218 ac Runoff Volume = 0.014 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.218 ac

Summary for Subcatchment 1S: Loc#10 Watershed

Runoff = 0.19 cfs @ 12.08 hrs, Volume= 0.014 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

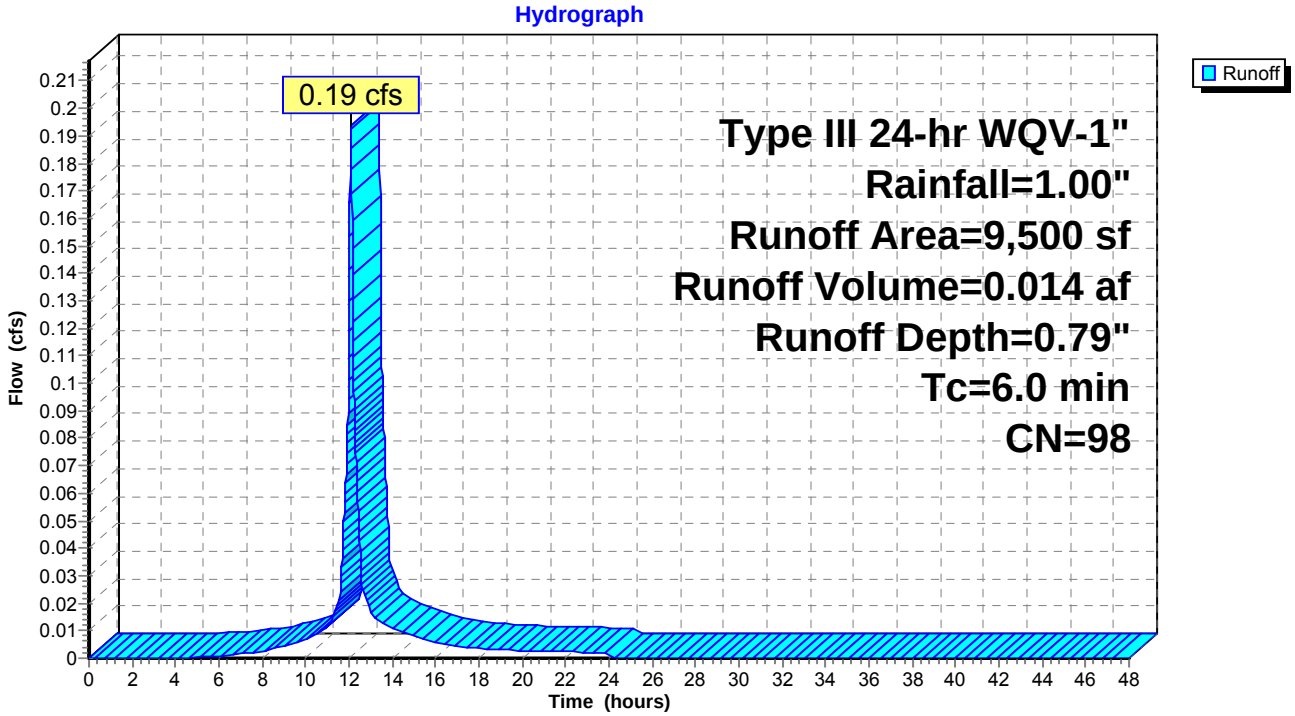
Area (sf)	CN	Description	Land Use
9,500	98	Paved parking, HSG A	Pavement
9,500		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
9,500	Pavement
9,500	Total

Subcatchment 1S: Loc#10 Watershed



Summary for Pond 2P: Leaching Basin

Inflow Area = 0.218 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.19 cfs @ 12.08 hrs, Volume= 0.014 af
Outflow = 0.19 cfs @ 12.09 hrs, Volume= 0.010 af, Atten= 0%, Lag= 0.5 min
Discarded = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Primary = 0.19 cfs @ 12.09 hrs, Volume= 0.010 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.15' @ 12.09 hrs Surf.Area= 50 sf Storage= 208 cf

Plug-Flow detention time= 162.7 min calculated for 0.010 af (68% of inflow)
Center-of-Mass det. time= 68.2 min (856.1 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	95.00'	250 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

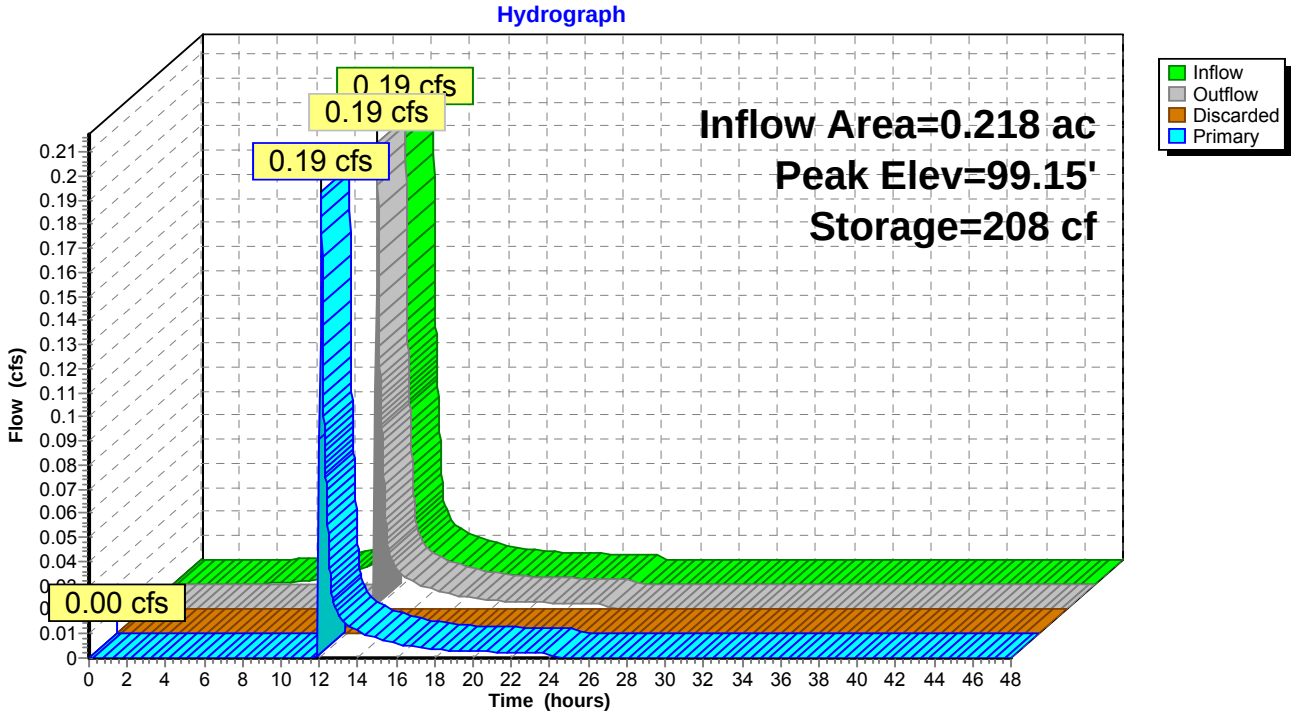
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
95.00	50	0	0
96.00	50	50	50
97.00	50	50	100
98.00	50	50	150
99.00	50	50	200
100.00	50	50	250

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**1.0' long x 1.00' rise Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	95.00'	**2.410 in/hr Exfiltration over Horizontal area above 95.00'** Conductivity to Groundwater Elevation = 91.00' Excluded Horizontal area = 50 sf Phase-In= 0.01'

Discarded OutFlow Max=0.00 cfs @ 0.00 hrs HW=95.00' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.19 cfs @ 12.09 hrs HW=99.15' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Weir Controls 0.19 cfs @ 1.27 fps)

Pond 2P: Leaching Basin



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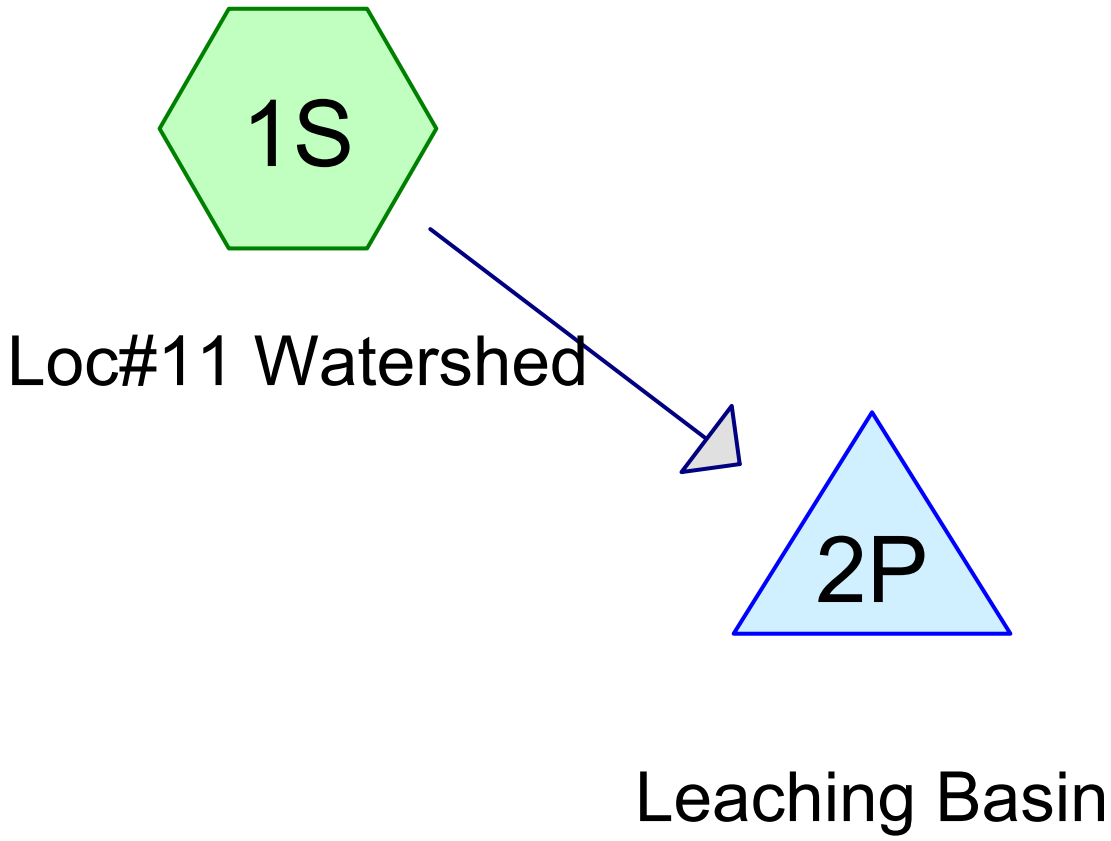
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 11

DCI PROJECT: 2016-055



Subcat Reach Pond Link

Drainage Diagram for OSV LOC-11
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.092	98	Paved parking, HSG A (1S)
0.092		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.092	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.092		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.092	Pavement	1S
0.092	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.092	Pavement	100.00	0.950	0.95
0.092	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#11 Watershed Runoff Area=4,000 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.08 cfs 0.006 af

Pond 2P: Leaching Basin Peak Elev=99.01' Storage=200 cf Inflow=0.08 cfs 0.006 af
Discarded=0.00 cfs 0.000 af Primary=0.00 cfs 0.001 af Outflow=0.00 cfs 0.001 af

Total Runoff Area = 0.092 ac Runoff Volume = 0.006 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.092 ac

Summary for Subcatchment 1S: Loc#11 Watershed

Runoff = 0.08 cfs @ 12.08 hrs, Volume= 0.006 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

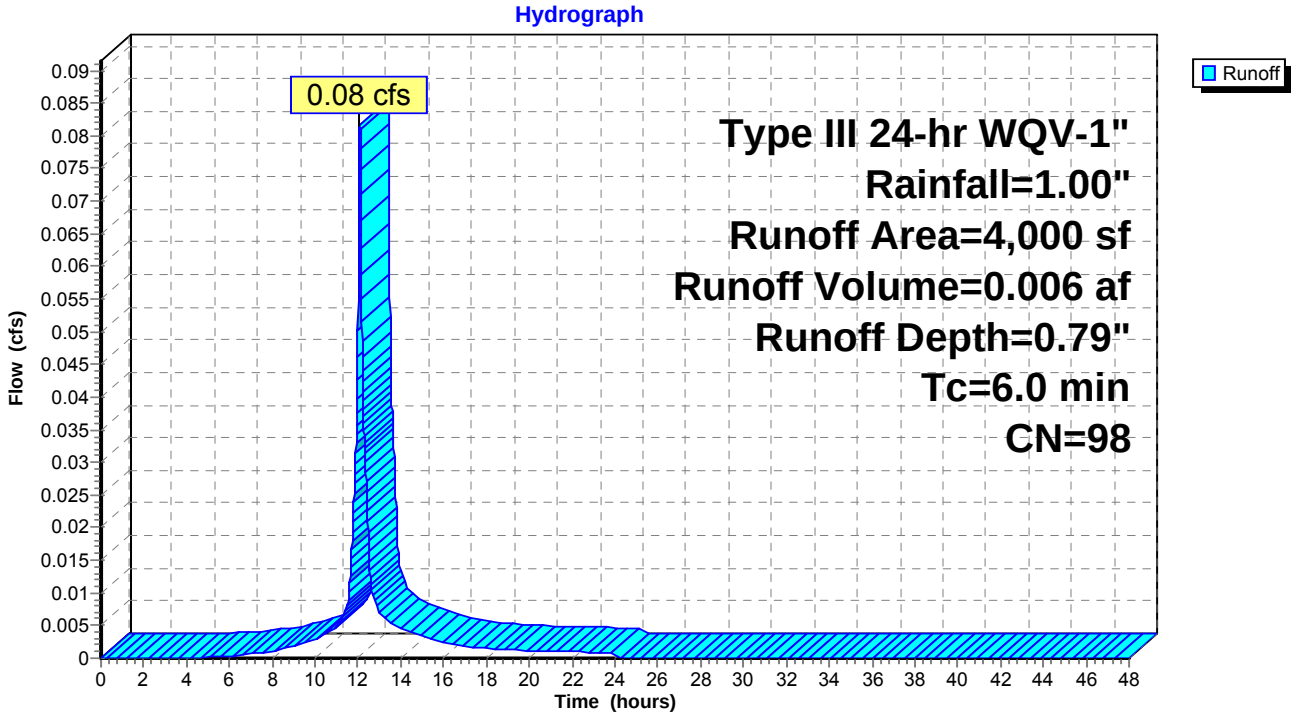
Area (sf)	CN	Description	Land Use
4,000	98	Paved parking, HSG A	Pavement
4,000		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
4,000	Pavement
4,000	Total

Subcatchment 1S: Loc#11 Watershed



Summary for Pond 2P: Leaching Basin

Inflow Area = 0.092 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.08 cfs @ 12.08 hrs, Volume= 0.006 af
Outflow = 0.00 cfs @ 14.00 hrs, Volume= 0.001 af, Atten= 94%, Lag= 115.0 min
Discarded = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Primary = 0.00 cfs @ 14.00 hrs, Volume= 0.001 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.01' @ 14.00 hrs Surf.Area= 50 sf Storage= 200 cf

Plug-Flow detention time= 429.0 min calculated for 0.001 af (24% of inflow)
Center-of-Mass det. time= 262.6 min (1,050.5 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	95.00'	250 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

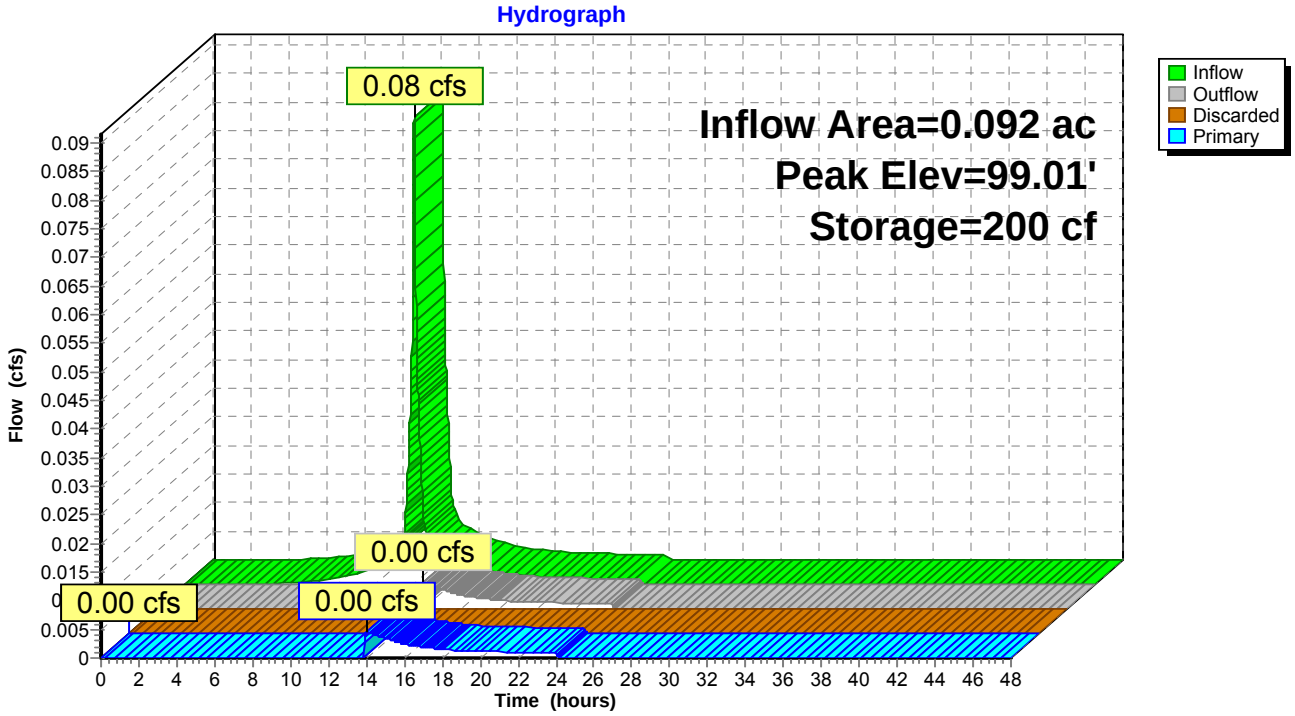
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
95.00	50	0	0
96.00	50	50	50
97.00	50	50	100
98.00	50	50	150
99.00	50	50	200
100.00	50	50	250

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**1.0' long x 1.00' rise Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	95.00'	**2.410 in/hr Exfiltration over Horizontal area above 95.00'** Conductivity to Groundwater Elevation = 91.00' Excluded Horizontal area = 50 sf Phase-In= 0.01'

Discarded OutFlow Max=0.00 cfs @ 0.00 hrs HW=95.00' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 14.00 hrs HW=99.01' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Weir Controls 0.00 cfs @ 0.26 fps)

Pond 2P: Leaching Basin



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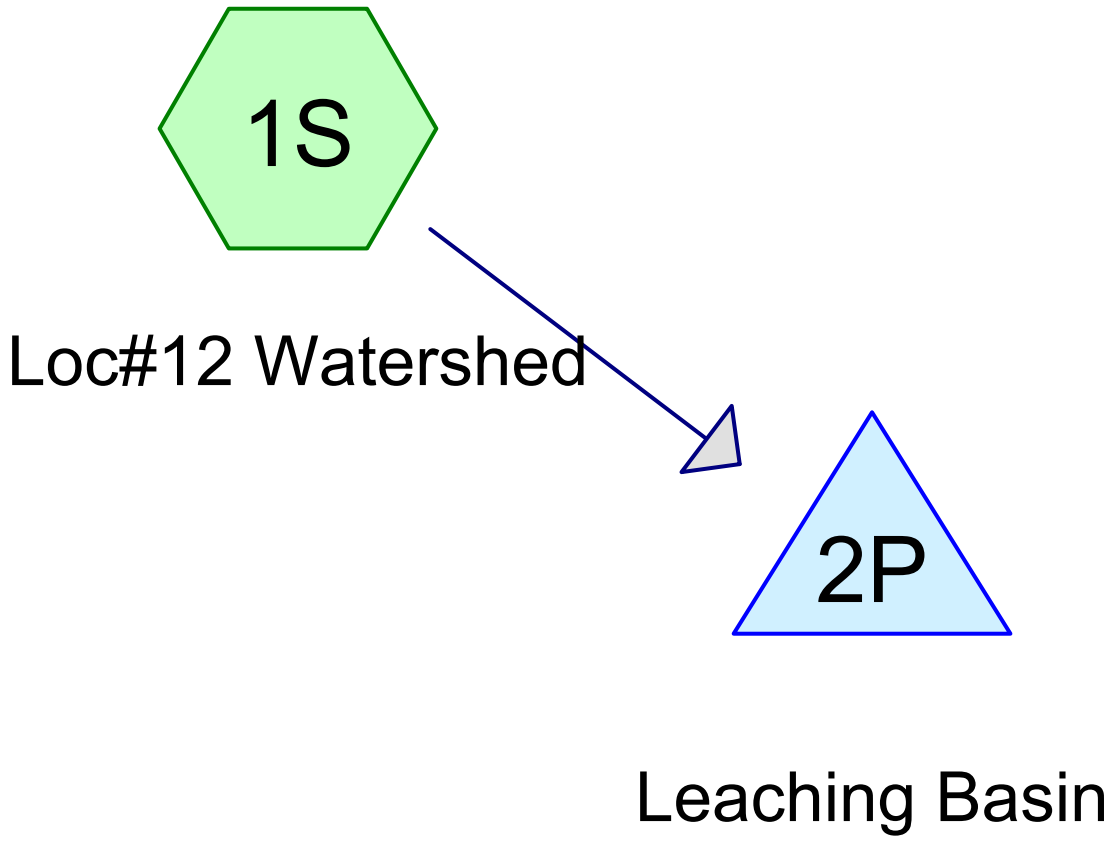
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 12

DCI PROJECT: 2016-055



Subcat Reach Pond Link

Drainage Diagram for OSV LOC-12
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.599	98	Paved parking, HSG A (1S)
0.599		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.599	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.599		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.599	Pavement	1S
0.599	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.599	Pavement	100.00	0.950	0.95
0.599	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#12 Watershed Runoff Area=26,100 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.53 cfs 0.039 af

Pond 2P: Leaching Basin Peak Elev=99.30' Storage=215 cf Inflow=0.53 cfs 0.039 af
Discarded=0.00 cfs 0.000 af Primary=0.53 cfs 0.035 af Outflow=0.53 cfs 0.035 af

Total Runoff Area = 0.599 ac Runoff Volume = 0.039 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.599 ac

Summary for Subcatchment 1S: Loc#12 Watershed

Runoff = 0.53 cfs @ 12.08 hrs, Volume= 0.039 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

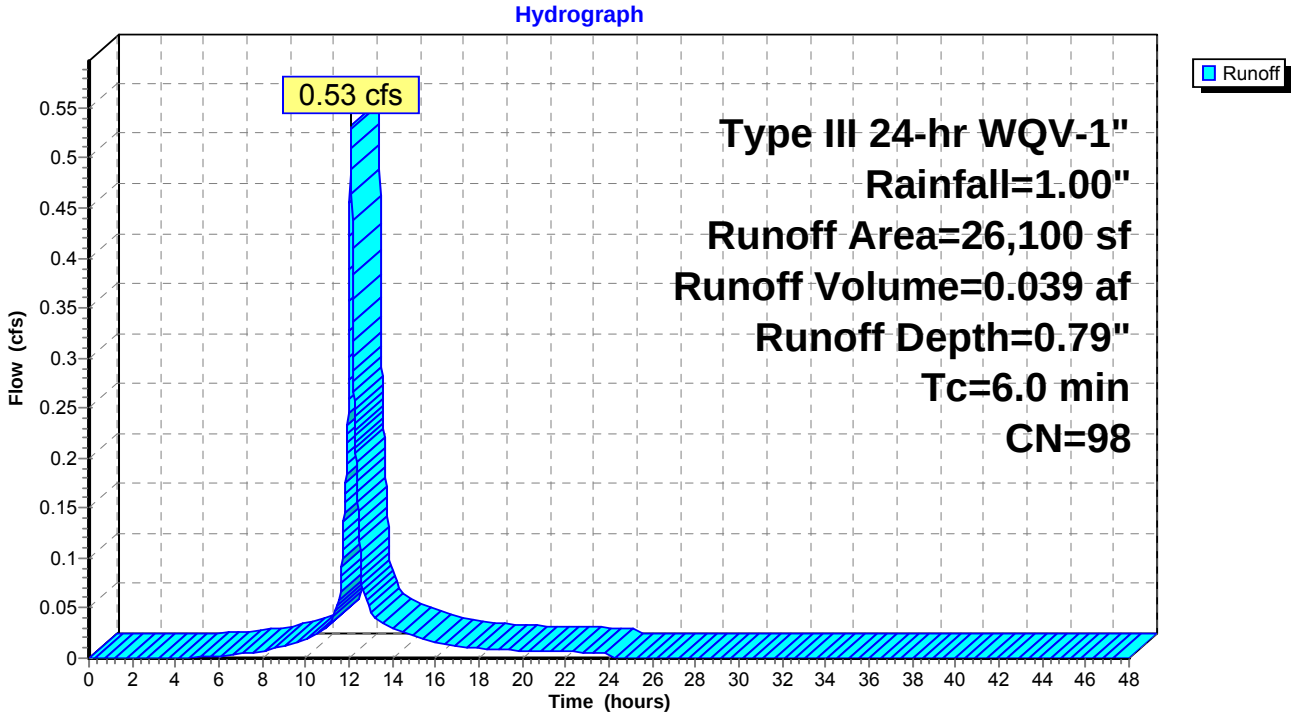
Area (sf)	CN	Description	Land Use
26,100	98	Paved parking, HSG A	Pavement
26,100		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
26,100	Pavement
26,100	Total

Subcatchment 1S: Loc#12 Watershed



Summary for Pond 2P: Leaching Basin

Inflow Area = 0.599 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.53 cfs @ 12.08 hrs, Volume= 0.039 af
Outflow = 0.53 cfs @ 12.09 hrs, Volume= 0.035 af, Atten= 0%, Lag= 0.3 min
Discarded = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Primary = 0.53 cfs @ 12.09 hrs, Volume= 0.035 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.30' @ 12.09 hrs Surf.Area= 50 sf Storage= 215 cf

Plug-Flow detention time= 86.4 min calculated for 0.035 af (88% of inflow)
Center-of-Mass det. time= 32.3 min (820.2 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	95.00'	250 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

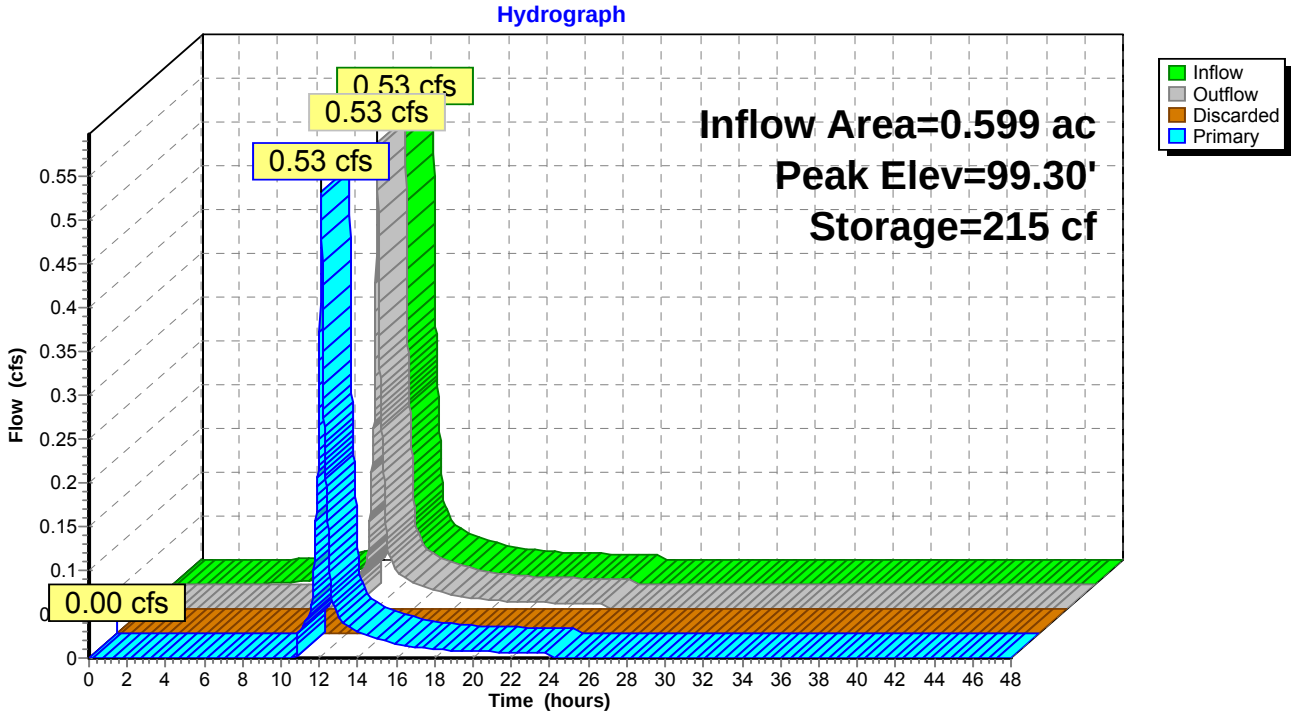
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
95.00	50	0	0
96.00	50	50	50
97.00	50	50	100
98.00	50	50	150
99.00	50	50	200
100.00	50	50	250

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**1.0' long x 1.00' rise Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	95.00'	**2.410 in/hr Exfiltration over Horizontal area above 95.00'** Conductivity to Groundwater Elevation = 91.00' Excluded Horizontal area = 50 sf Phase-In= 0.01'

Discarded OutFlow Max=0.00 cfs @ 0.00 hrs HW=95.00' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.53 cfs @ 12.09 hrs HW=99.30' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Weir Controls 0.53 cfs @ 1.79 fps)

Pond 2P: Leaching Basin



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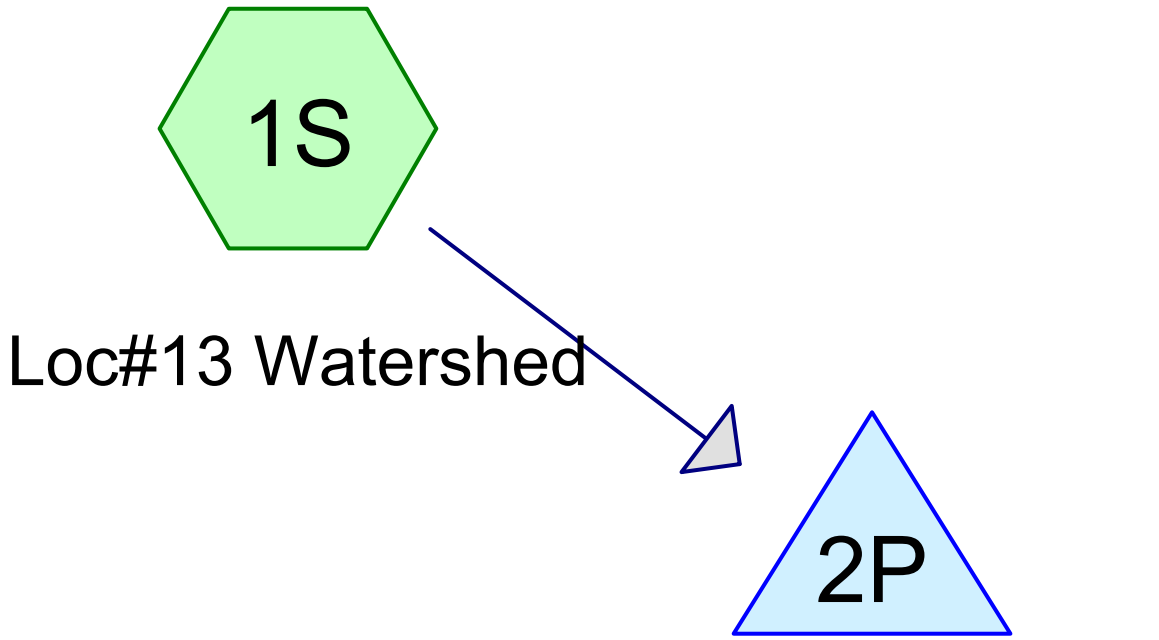
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 13

DCI PROJECT: 2016-055



Subcat Reach Pond Link

Drainage Diagram for OSV LOC-13
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.122	98	Paved parking, HSG A (1S)
0.122		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.122	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.122		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.122	Pavement	1S
0.122	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.122	Pavement	100.00	0.950	0.95
0.122	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#13 Watershed Runoff Area=5,300 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.11 cfs 0.008 af

Pond 2P: Bioretention Pond Peak Elev=99.34' Storage=102 cf Inflow=0.11 cfs 0.008 af
Discarded=0.02 cfs 0.008 af Primary=0.00 cfs 0.000 af Outflow=0.02 cfs 0.008 af

Total Runoff Area = 0.122 ac Runoff Volume = 0.008 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.122 ac

Summary for Subcatchment 1S: Loc#13 Watershed

Runoff = 0.11 cfs @ 12.08 hrs, Volume= 0.008 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

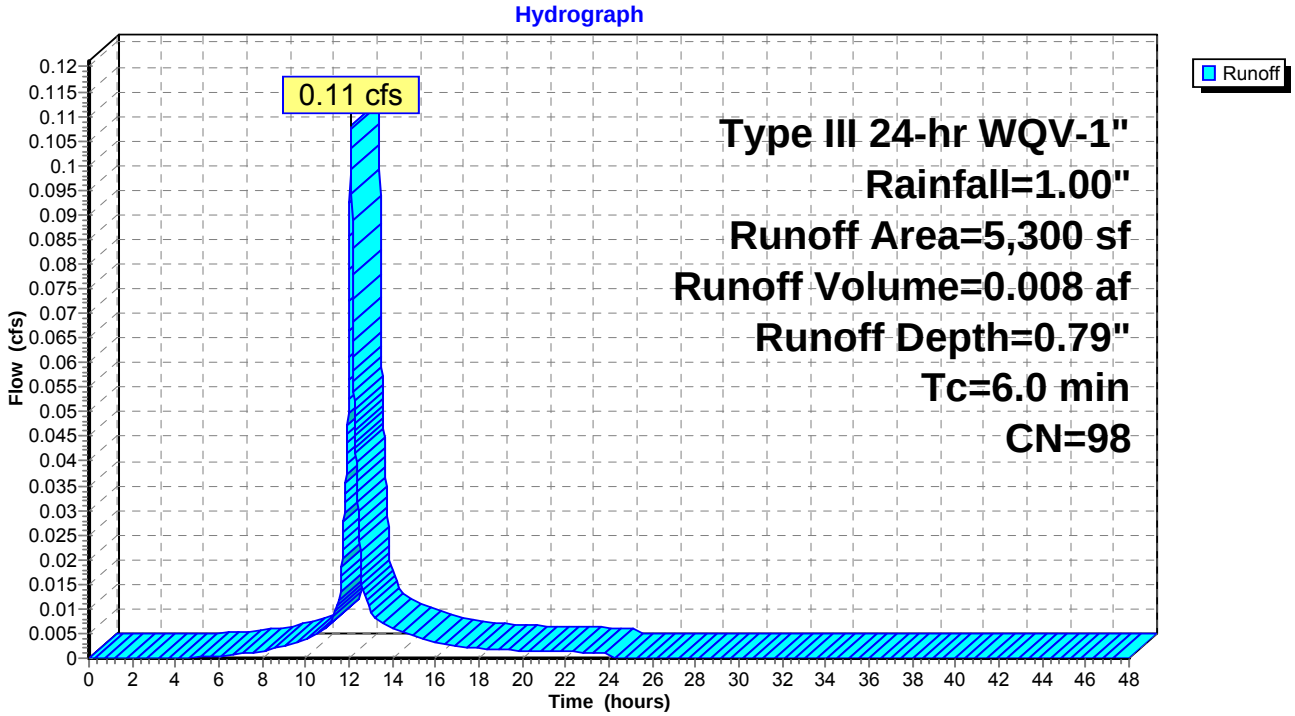
Area (sf)	CN	Description	Land Use
5,300	98	Paved parking, HSG A	Pavement
5,300		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
5,300	Pavement
5,300	Total

Subcatchment 1S: Loc#13 Watershed



Summary for Pond 2P: Bioretention Pond

Inflow Area = 0.122 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.11 cfs @ 12.08 hrs, Volume= 0.008 af
Outflow = 0.02 cfs @ 12.55 hrs, Volume= 0.008 af, Atten= 83%, Lag= 28.2 min
Discarded = 0.02 cfs @ 12.55 hrs, Volume= 0.008 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.34' @ 12.55 hrs Surf.Area= 300 sf Storage= 102 cf

Plug-Flow detention time= 36.8 min calculated for 0.008 af (100% of inflow)
Center-of-Mass det. time= 36.8 min (824.6 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	300 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

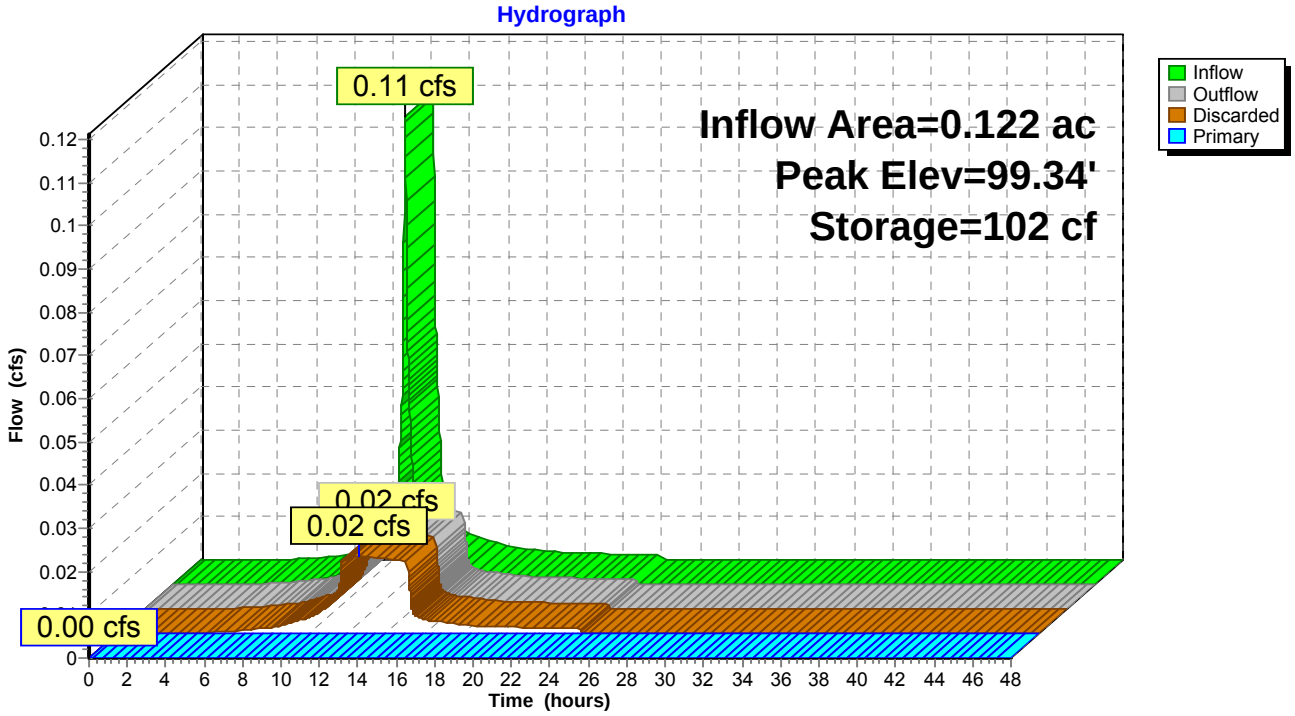
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	300	0	0
100.00	300	300	300

Device	Routing	Invert	Outlet Devices
#1	Primary	100.60'	**3.0' long Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	99.00'	**2.410 in/hr Exfiltration over Horizontal area above 98.00'** Conductivity to Groundwater Elevation = 94.00' Excluded Horizontal area = 0 sf Phase-In= 0.01'

Discarded OutFlow Max=0.02 cfs @ 12.55 hrs HW=99.34' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.02 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=99.00' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Controls 0.00 cfs)

Pond 2P: Bioretention Pond



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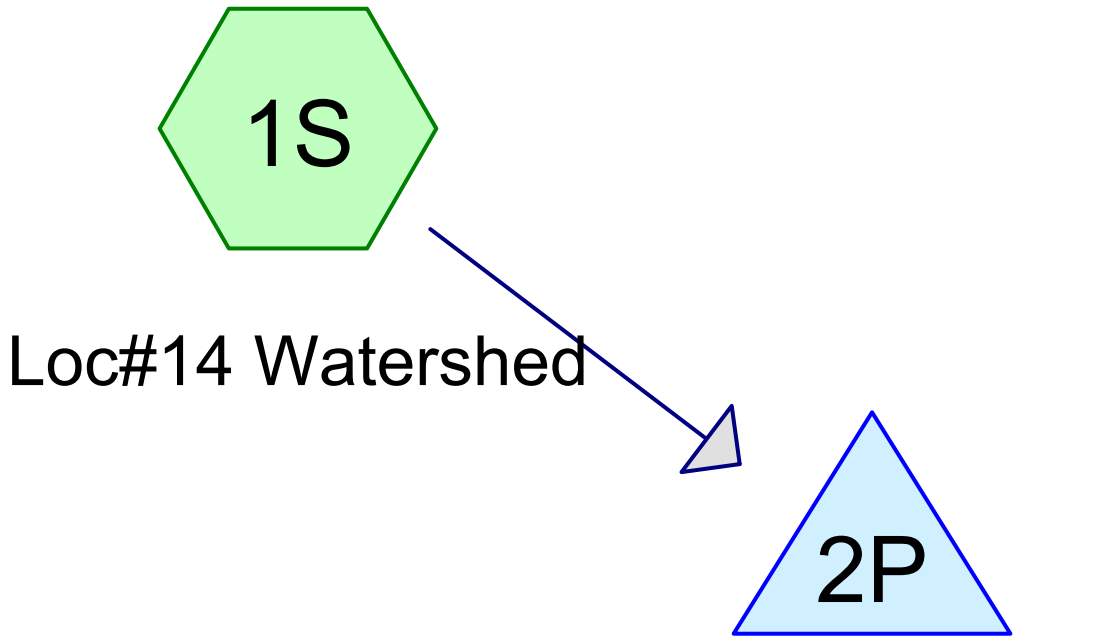
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 14

DCI PROJECT: 2016-055



Subcat Reach Pond Link

Drainage Diagram for OSV LOC-14
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.158	98	Paved parking, HSG A (1S)
0.158		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.158	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.158		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.158	Pavement	1S
0.158	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.158	Pavement	100.00	0.950	0.95
0.158	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#14 Watershed Runoff Area=6,900 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.14 cfs 0.010 af

Pond 2P: Leaching Basin Peak Elev=99.10' Storage=205 cf Inflow=0.14 cfs 0.010 af
Discarded=0.00 cfs 0.000 af Primary=0.10 cfs 0.006 af Outflow=0.10 cfs 0.006 af

Total Runoff Area = 0.158 ac Runoff Volume = 0.010 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.158 ac

Summary for Subcatchment 1S: Loc#14 Watershed

Runoff = 0.14 cfs @ 12.08 hrs, Volume= 0.010 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

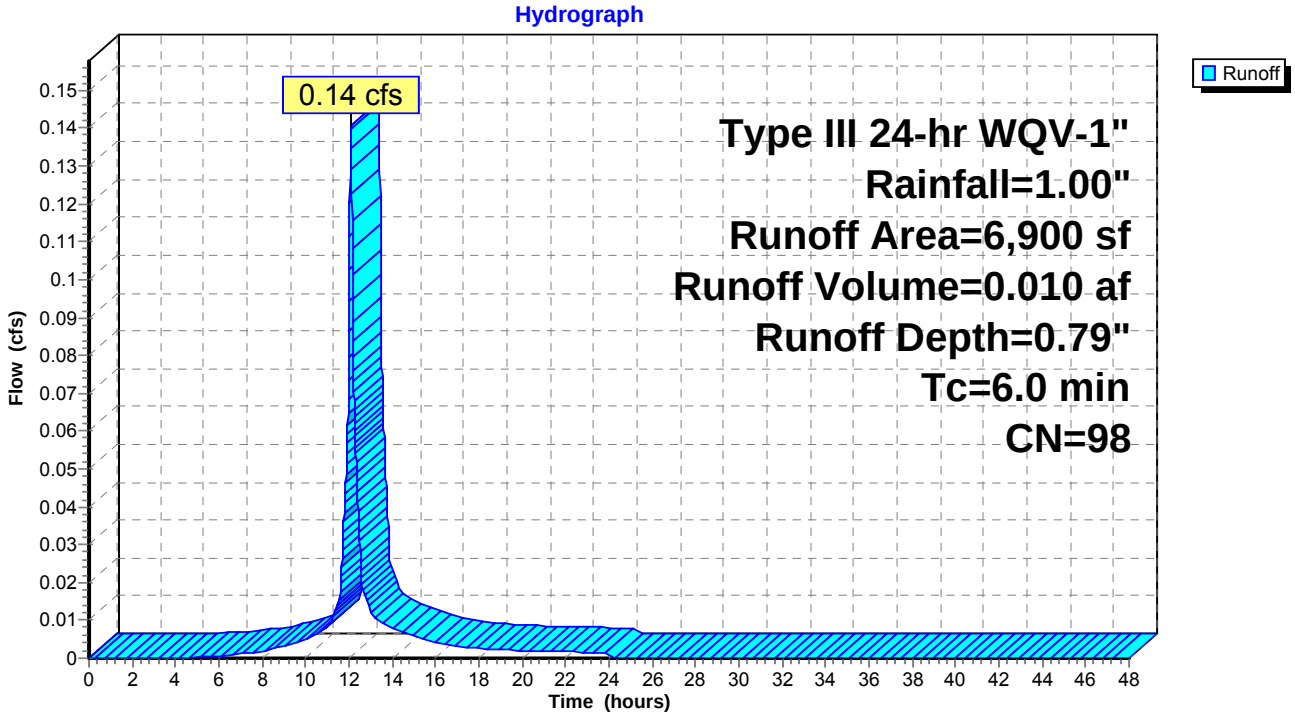
Area (sf)	CN	Description	Land Use
6,900	98	Paved parking, HSG A	Pavement
6,900		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
6,900	Pavement
6,900	Total

Subcatchment 1S: Loc#14 Watershed



Summary for Pond 2P: Leaching Basin

Inflow Area = 0.158 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.14 cfs @ 12.08 hrs, Volume= 0.010 af
Outflow = 0.10 cfs @ 12.16 hrs, Volume= 0.006 af, Atten= 27%, Lag= 4.5 min
Discarded = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Primary = 0.10 cfs @ 12.16 hrs, Volume= 0.006 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.10' @ 12.16 hrs Surf.Area= 50 sf Storage= 205 cf

Plug-Flow detention time= 203.8 min calculated for 0.006 af (56% of inflow)
Center-of-Mass det. time= 96.4 min (884.3 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	95.00'	250 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

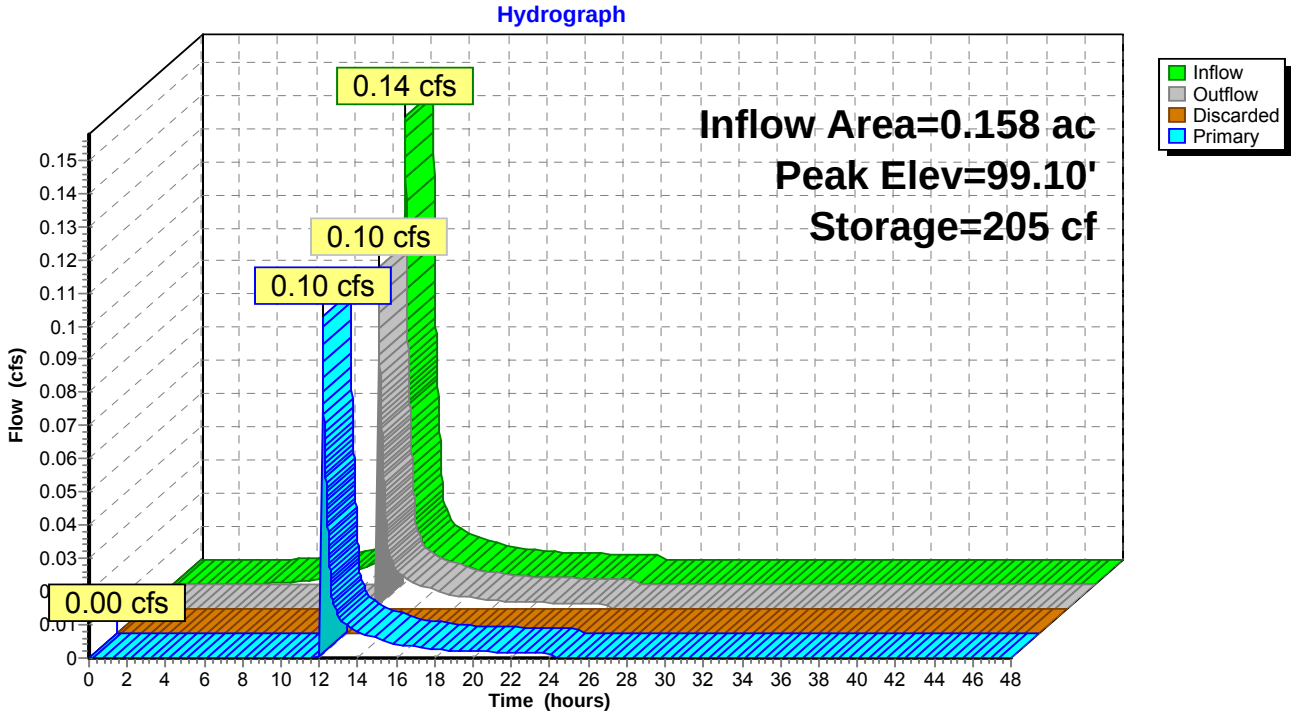
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
95.00	50	0	0
96.00	50	50	50
97.00	50	50	100
98.00	50	50	150
99.00	50	50	200
100.00	50	50	250

Device	Routing	Invert	Outlet Devices
#1	Primary	99.00'	**1.0' long x 1.00' rise Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	95.00'	**2.410 in/hr Exfiltration over Horizontal area above 95.00'** Conductivity to Groundwater Elevation = 91.00' Excluded Horizontal area = 50 sf Phase-In= 0.01'

Discarded OutFlow Max=0.00 cfs @ 0.00 hrs HW=95.00' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.10 cfs @ 12.16 hrs HW=99.10' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Weir Controls 0.10 cfs @ 1.03 fps)

Pond 2P: Leaching Basin



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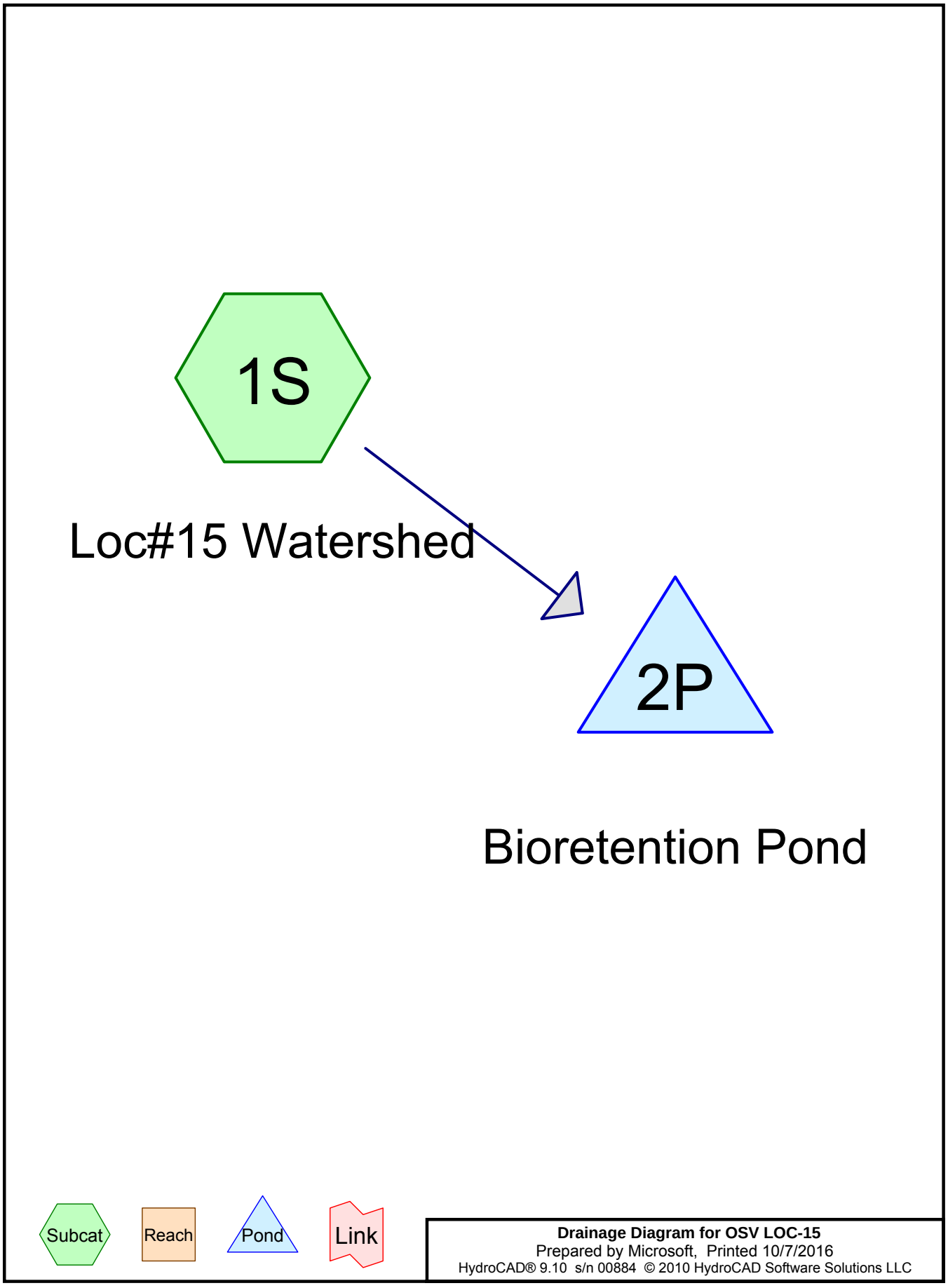
STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 15

DCI PROJECT: 2016-055



Drainage Diagram for OSV LOC-15
Prepared by Microsoft, Printed 10/7/2016

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.188	98	Paved parking, HSG A (1S)
0.188		**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.188	HSG A	1S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
0.188		**TOTAL AREA**

Land-Use Listing (all nodes)

Area (acres)	Land Use	Subcatchment Numbers
0.188	Pavement	1S
0.188	**TOTAL**	

Pollutant Concentrations

Line#	Land Use
1	Pavement

Subcatchment Loading

Line#	Subcat Number
1	1S
	TOTAL

Pollutant Loading for 1.00" Rainfall, Pj=1.000, Project 100.00% Impervious (all nodes)

Area (acres)	Land Use	Imp. (%)	Rv	Runoff (inches)
0.188	Pavement	100.00	0.950	0.95
0.188	**TOTAL**			

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Loc#15 Watershed Runoff Area=8,200 sf 100.00% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=98 Runoff=0.17 cfs 0.012 af

Pond 2P: Bioretention Pond Peak Elev=99.85' Storage=205 cf Inflow=0.17 cfs 0.012 af
Discarded=0.02 cfs 0.012 af Primary=0.00 cfs 0.000 af Outflow=0.02 cfs 0.012 af

Total Runoff Area = 0.188 ac Runoff Volume = 0.012 af Average Runoff Depth = 0.79"
0.00% Pervious = 0.000 ac 100.00% Impervious = 0.188 ac

Summary for Subcatchment 1S: Loc#15 Watershed

Runoff = 0.17 cfs @ 12.08 hrs, Volume= 0.012 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr WQV-1" Rainfall=1.00"

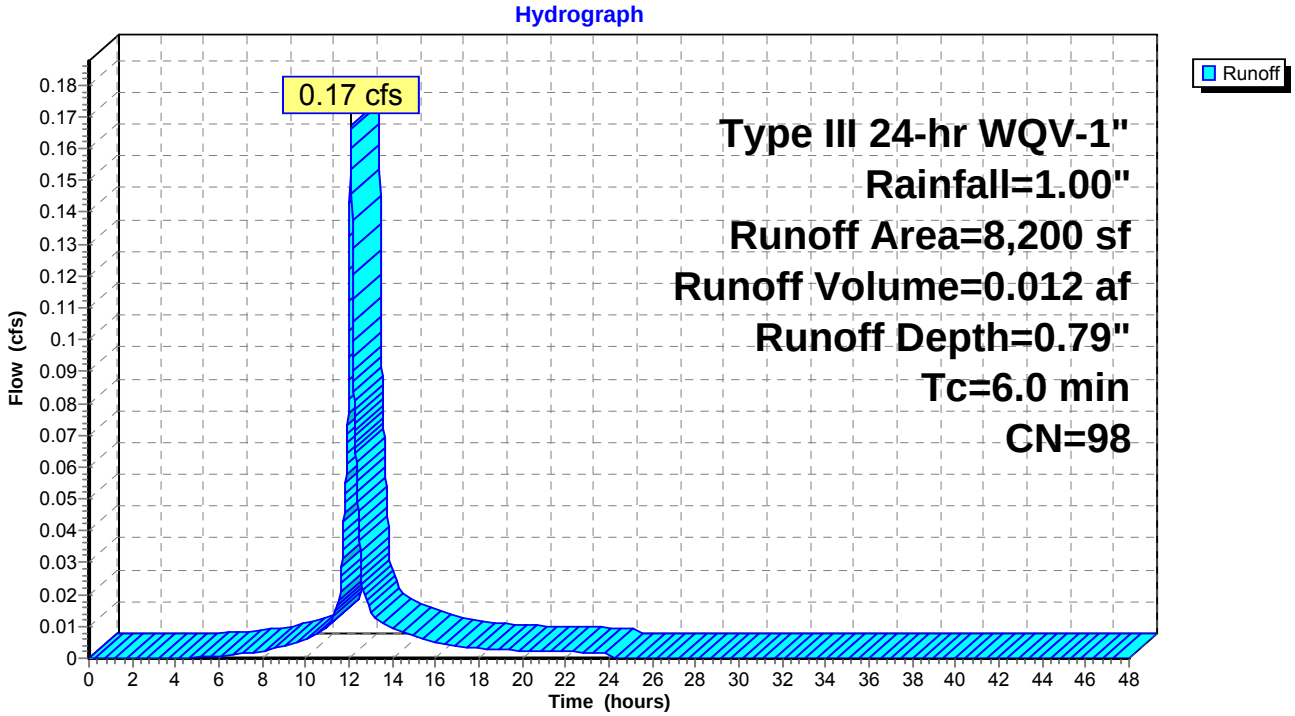
Area (sf)	CN	Description	Land Use
8,200	98	Paved parking, HSG A	Pavement
8,200		100.00% Impervious Area	

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Use 6 min (Tc less than 6)**

Pollutant Loading for 1.00" Rainfall, Pj=1.000
Project 100.00% Impervious, Rv= 0.950, Runoff= 0.95"

Area (sq-ft)	Land Use
8,200	Pavement
8,200	Total

Subcatchment 1S: Loc#15 Watershed



Summary for Pond 2P: Bioretention Pond

Inflow Area = 0.188 ac,100.00% Impervious, Inflow Depth = 0.79" for WQV-1" event
Inflow = 0.17 cfs @ 12.08 hrs, Volume= 0.012 af
Outflow = 0.02 cfs @ 12.94 hrs, Volume= 0.012 af, Atten= 91%, Lag= 51.3 min
Discarded = 0.02 cfs @ 12.94 hrs, Volume= 0.012 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 99.85' @ 12.94 hrs Surf.Area= 240 sf Storage= 205 cf

Plug-Flow detention time= 104.9 min calculated for 0.012 af (100% of inflow)
Center-of-Mass det. time= 104.9 min (892.8 - 787.9)

Volume	Invert	Avail.Storage	Storage Description
#1	99.00'	240 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

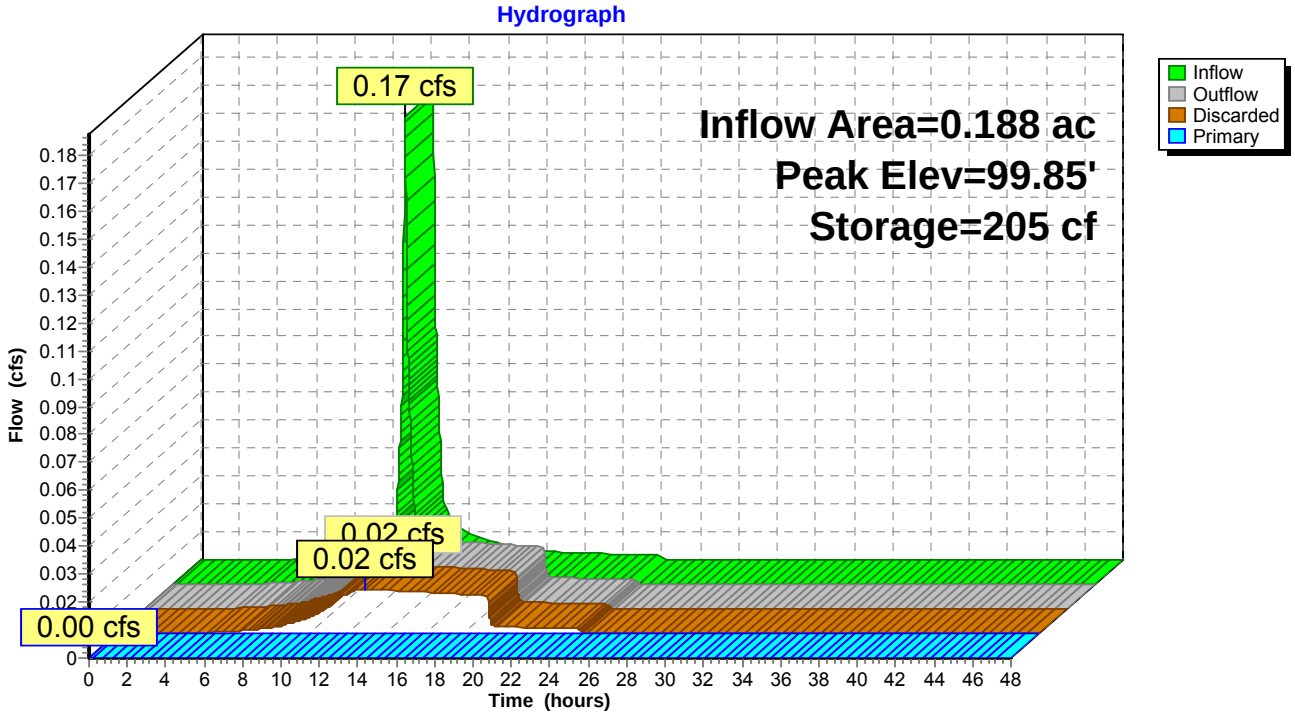
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
99.00	240	0	0
100.00	240	240	240

Device	Routing	Invert	Outlet Devices
#1	Primary	100.60'	**3.0' long Sharp-Crested Vee/Trap Weir** C= 2.62
#2	Discarded	99.00'	**2.410 in/hr Exfiltration over Horizontal area above 98.00'** Conductivity to Groundwater Elevation = 94.00' Excluded Horizontal area = 0 sf Phase-In= 0.01'

Discarded OutFlow Max=0.02 cfs @ 12.94 hrs HW=99.85' (Free Discharge)
↑—**2=Exfiltration** (Controls 0.02 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=99.00' (Free Discharge)
↑—**1=Sharp-Crested Vee/Trap Weir** (Controls 0.00 cfs)

Pond 2P: Bioretention Pond



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STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 16

DCI PROJECT: 2016-055

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STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE
STURBRIDGE, MA

DATE: 10.3.16

LOCATION NO. 17

DCI PROJECT: 2016-055

The Simple Method Loading Calculation and Reduction Calculation Worksheet (OS-1)

Design Consultants, Inc.

No.	Watershed Name	Landuse	Area (acres)	Sanded?	Sanded Area (acres)	% Impervious	Runoff (in)	Annual Runoff (cf)	Annual TSS (lbs)	Annual TP (lbs)	Annual TN (lbs)
1	Loc 1-Bioswale	Roadway/Parking Lot	1.81	Yes	1.81	80	33	218,554	9,050	6.80	40.8
2	Loc 3-Bioswale	Roadway/Parking Lot	0.25	Yes	0.25	80	33	29,946	1,240	0.93	5.6
3	Loc 4-Bioswale	Roadway/Parking Lot	0.23	Yes	0.23	80	33	27,772	1,150	0.86	5.2
4	Loc 5-Bioswale	Roadway/Parking Lot	0.39	Yes	0.39	80	33	47,092	1,950	1.47	8.8
5						0	0	0	0	0.00	0.0
6						0	0	0	0	0.00	0.0
7						0	0	0	0	0.00	0.0
8						0	0	0	0	0.00	0.0
9						0	0	0	0	0.00	0.0
10						0	0	0	0	0.00	0.0
11						0	0	0	0	0.00	0.0
12						0	0	0	0	0.00	0.0
13						0	0	0	0	0.00	0.0
14						0	0	0	0	0.00	0.0
15						0	0	0	0	0.00	0.0
Total			3		3			323,364	**13,390**	**10.1**	**60.4**

Landuse[1]	% Impervious	TSS (mg/l)	TP (mg/l)	TN (mg/l)
Commerical	85	75	0.2	2
Industrial	75	120	0.4	2.5
Multifamily	60	100	0.4	2.2
Open Urban Land	9	48.5	0.31	0.74
Residential-High Density	40	100	0.4	2.2
Residential-Low Density	10	100	0.4	2.2
Residential-Med. Density	30	100	0.4	2.2
Residential Roof	100	19	0.11	1.5
Roadway/Parking Lot	80	150	0.5	3

[1] High density residential (<1/4 acre lots); Medium density residential (1/4 to 1/2 acre lots); Low density residential (>1 acre lots); Multifamily (>7 dwellings per acre).

Annual Rainfall	48	inches; user specified
P_j	0.9	%; default
Sanding Rate	500	lbs/acre; default
Sanding Applications	10	times/year; default

Simple Method Equations:

L = 0.226 * R * C * A

Where:
L = Annual Load (lbs)
R = Annual Runoff (inches)
C = Pollutant Concentration (mg/l)
A = Area (acres)
0.226 = Unit Conversion Factor

$R = P * P_j * Rv$

Where:
R = Annual Runoff (inches)
P = Annual Rainfall (inches)
P_j = % of rainfall events producing runoff
Rv = Runoff Coefficient

Rv = 0.05+0.9 * Ia

Ia = Impervious Fraction (%)

References:

Pitt, Robert. (2004, February 16). The National Stormwater Quality Database (NSQD, version 1.1). Retrieved July 22, 2005 from the World Wide Web: http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/recentpaper.htm

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The Simple Method to Calculate Urban Stormwater Loads. Retrieved July 22, 2005 from the World Wide Web: http://www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm

The Simple Method Loading Calculation and Reduction Calculation Worksheet (OS-1)

Design Consultants, Inc.

No.	Watershed Name	BMP Type	BMP Drainage Area (acres)	TSS Removal (%)	TP Removal (%)	TN Removal (%)	Annual TSS Removed (lbs)	Annual TP Removed (lbs)	Annual TN Removed (lbs)
1	Loc 1-Bioswale	Raingarden - 1"	1.81	90%	65%	58%	8,145	4.42	23.7
2	Loc 3-Bioswale	Raingarden - 1"	0.25	90%	65%	58%	1,125	0.61	3.3
3	Loc 4-Bioswale	Raingarden - 1"	0.23	90%	65%	58%	1,035	0.56	3.0
4	Loc 5-Bioswale	Raingarden - 1"	0.39	90%	65%	58%	1,755	0.95	5.1
5							0	0.00	0.0
6							0	0.00	0.0
7							0	0.00	0.0
8							0	0.00	0.0
9							0	0.00	0.0
10							0	0.00	0.0
11							0	0.00	0.0
12							0	0.00	0.0
13							0	0.00	0.0
14							0	0.00	0.0
15							0	0.00	0.0
Total							**12,060**	**6.55**	**35.1**

BMP Type	TSS Removal (%)	TP Removal (%)	TN Removal (%)
Baffle Tank	70%	30%	0%
Constructed Wetland	80%	55%	30%
Detention Basin (dry)	48%	30%	30%
Infiltration - 1"	80%	70%	70%
Raingarden - 1"	90%	65%	58%
Swale	48%	30%	30%

References:

Comparative Pollutant Removal Capability of Stormwater Treatment Practices, Technical Note #95 from Watershed Protection Techniques. 2(4): 515-520, Article 64. Retrieved July 22, 2005 from the World Wide Web: http://www.stormwatercenter.net/Practice/64-Comparative%20Pollutant%20Removal.pdf

Choi, J & Engel, B. Urban BMPs and Cost Estimation, Structural BMP Expected Pollutant Removal Efficiency & Median Event Mean Concentration for Urban Land Uses. US EPA. (1993) Handbook Urban Runoff Pollution and Control Planning. Retrieved July 22, 2005 from the World Wide Web: http://danpatch.ecn.purdue.edu/~jychoi/ubmp0/emc2.htm

The Simple Method Loading Calculation and Reduction Calculation Worksheet (OS-2)

Design Consultants, Inc.

No.	Watershed Name	Landuse	Area (acres)	Sanded?	Sanded Area (acres)	% Impervious	Runoff (in)	Annual Runoff (cf)	Annual TSS (lbs)	Annual TP (lbs)	Annual TN (lbs)
1	Loc 2-Detention	Roadway/Parking Lot	3.00	No	0.00	80	33	362,245	3,383	11.28	67.7
2						0	0	0	0	0.00	0.0
3						0	0	0	0	0.00	0.0
4						0	0	0	0	0.00	0.0
5						0	0	0	0	0.00	0.0
6						0	0	0	0	0.00	0.0
7						0	0	0	0	0.00	0.0
8						0	0	0	0	0.00	0.0
9						0	0	0	0	0.00	0.0
10						0	0	0	0	0.00	0.0
11						0	0	0	0	0.00	0.0
12						0	0	0	0	0.00	0.0
13						0	0	0	0	0.00	0.0
14						0	0	0	0	0.00	0.0
15						0	0	0	0	0.00	0.0
Total			3		0			362,245	**3,383**	**11.3**	**67.7**

Landuse[1]	% Impervious	TSS (mg/l)	TP (mg/l)	TN (mg/l)
Commerical	85	75	0.2	2
Industrial	75	120	0.4	2.5
Multifamily	60	100	0.4	2.2
Open Urban Land	9	48.5	0.31	0.74
Residential-High Density	40	100	0.4	2.2
Residential-Low Density	10	100	0.4	2.2
Residential-Med. Density	30	100	0.4	2.2
Residential Roof	100	19	0.11	1.5
Roadway/Parking Lot	80	150	0.5	3

[1] High density residential (<1/4 acre lots); Medium density residential (1/4 to 1/2 acre lots); Low density residential (>1 acre lots); Multifamily (>7 dwellings per acre).

Annual Rainfall	48	inches; user specified
P_j	0.9	%; default
Sanding Rate	500	lbs/acre; default
Sanding Applications	10	times/year; default

Simple Method Equations:

L = 0.226 * R * C * A

Where:
L = Annual Load (lbs)
R = Annual Runoff (inches)
C = Pollutant Concentration (mg/l)
A = Area (acres)
0.226 = Unit Conversion Factor

$R = P * P_j * Rv$

Where:
R = Annual Runoff (inches)
P = Annual Rainfall (inches)
P_j = % of rainfall events producing runoff
Rv = Runoff Coefficient

Rv = 0.05+0.9 * Ia

Ia = Impervious Fraction (%)

References:

Pitt, Robert. (2004, February 16). The National Stormwater Quality Database (NSQD, version 1.1). Retrieved July 22, 2005 from the World Wide Web: http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/recentpaper.htm

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The Simple Method to Calculate Urban Stormwater Loads. Retrieved July 22, 2005 from the World Wide Web: http://www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm

The Simple Method Loading Calculation and Reduction Calculation Worksheet (OS-2)

Design Consultants, Inc.

No.	Watershed Name	BMP Type	BMP Drainage Area (acres)	TSS Removal (%)	TP Removal (%)	TN Removal (%)	Annual TSS Removed (lbs)	Annual TP Removed (lbs)	Annual TN Removed (lbs)
1	Loc 2-Detention	Detention Basin (dry)	3	48%	30%	30%	1,624	3.38	20.3
2							0	0.00	0.0
3							0	0.00	0.0
4							0	0.00	0.0
5							0	0.00	0.0
6							0	0.00	0.0
7							0	0.00	0.0
8							0	0.00	0.0
9							0	0.00	0.0
10							0	0.00	0.0
11							0	0.00	0.0
12							0	0.00	0.0
13							0	0.00	0.0
14							0	0.00	0.0
15							0	0.00	0.0
Total							**1,624**	**3.38**	**20.3**

BMP Type	TSS Removal (%)	TP Removal (%)	TN Removal (%)
Baffle Tank	70%	30%	0%
Constructed Wetland	80%	55%	30%
Detention Basin (dry)	48%	30%	30%
Infiltration - 1"	80%	70%	70%
Raingarden - 1"	90%	65%	58%
Swale	48%	30%	30%

References:

Comparative Pollutant Removal Capability of Stormwater Treatment Practices, Technical Note #95 from Watershed Protection Techniques. 2(4): 515-520, Article 64. Retrieved July 22, 2005 from the World Wide Web: http://www.stormwatercenter.net/Practice/64-Comparative%20Pollutant%20Removal.pdf

Choi, J & Engel, B. Urban BMPs and Cost Estimation, Structural BMP Expected Pollutant Removal Efficiency & Median Event Mean Concentration for Urban Land Uses. US EPA. (1993) Handbook Urban Runoff Pollution and Control Planning. Retrieved July 22, 2005 from the World Wide Web: http://danpatch.ecn.purdue.edu/~jychoi/ubmp0/emc2.htm

The Simple Method Loading Calculation and Reduction Calculation Worksheet (OS-3)

Design Consultants, Inc.

No.	Watershed Name	Landuse	Area (acres)	Sanded?	Sanded Area (acres)	% Impervious	Runoff (in)	Annual Runoff (cf)	Annual TSS (lbs)	Annual TP (lbs)	Annual TN (lbs)
1	Loc 6-Bioswale	Roadway/Parking Lot	0.35	Yes	0.35	80	33	42,745	1,770	1.33	8.0
2						0	0	0	0	0.00	0.0
3						0	0	0	0	0.00	0.0
4						0	0	0	0	0.00	0.0
5						0	0	0	0	0.00	0.0
6						0	0	0	0	0.00	0.0
7						0	0	0	0	0.00	0.0
8						0	0	0	0	0.00	0.0
9						0	0	0	0	0.00	0.0
10						0	0	0	0	0.00	0.0
11						0	0	0	0	0.00	0.0
12						0	0	0	0	0.00	0.0
13						0	0	0	0	0.00	0.0
14						0	0	0	0	0.00	0.0
15						0	0	0	0	0.00	0.0
Total			0		0			42,745	**1,770**	**1.3**	**8.0**

Landuse[1]	% Impervious	TSS (mg/l)	TP (mg/l)	TN (mg/l)
Commerical	85	75	0.2	2
Industrial	75	120	0.4	2.5
Multifamily	60	100	0.4	2.2
Open Urban Land	9	48.5	0.31	0.74
Residential-High Density	40	100	0.4	2.2
Residential-Low Density	10	100	0.4	2.2
Residential-Med. Density	30	100	0.4	2.2
Residential Roof	100	19	0.11	1.5
Roadway/Parking Lot	80	150	0.5	3

[1] High density residential (<1/4 acre lots); Medium density residential (1/4 to 1/2 acre lots); Low density residential (>1 acre lots); Multifamily (>7 dwellings per acre).

Annual Rainfall	48	inches; user specified
P_j	0.9	%; default
Sanding Rate	500	lbs/acre; default
Sanding Applications	10	times/year; default

Simple Method Equations:

L = 0.226 * R * C * A

Where:
L = Annual Load (lbs)
R = Annual Runoff (inches)
C = Pollutant Concentration (mg/l)
A = Area (acres)
0.226 = Unit Conversion Factor

$R = P * P_j * Rv$

Where:
R = Annual Runoff (inches)
P = Annual Rainfall (inches)
P_j = % of rainfall events producing runoff
Rv = Runoff Coefficient

Rv = 0.05+0.9 * Ia

Ia = Impervious Fraction (%)

References:

Pitt, Robert. (2004, February 16). The National Stormwater Quality Database (NSQD, version 1.1). Retrieved July 22, 2005 from the World Wide Web: http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/recentpaper.htm

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The Simple Method to Calculate Urban Stormwater Loads. Retrieved July 22, 2005 from the World Wide Web: http://www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm

The Simple Method Loading Calculation and Reduction Calculation Worksheet (OS-3)

Design Consultants, Inc.

No.	Watershed Name	BMP Type	BMP Drainage Area (acres)	TSS Removal (%)	TP Removal (%)	TN Removal (%)	Annual TSS Removed (lbs)	Annual TP Removed (lbs)	Annual TN Removed (lbs)
1	Loc 6-Bioswale	Raingarden - 1"	0.354	90%	65%	58%	1,593	0.86	4.6
2							0	0.00	0.0
3							0	0.00	0.0
4							0	0.00	0.0
5							0	0.00	0.0
6							0	0.00	0.0
7							0	0.00	0.0
8							0	0.00	0.0
9							0	0.00	0.0
10							0	0.00	0.0
11							0	0.00	0.0
12							0	0.00	0.0
13							0	0.00	0.0
14							0	0.00	0.0
15							0	0.00	0.0
Total							**1,593**	**0.86**	**4.6**

BMP Type	TSS Removal (%)	TP Removal (%)	TN Removal (%)
Baffle Tank	70%	30%	0%
Constructed Wetland	80%	55%	30%
Detention Basin (dry)	48%	30%	30%
Infiltration - 1"	80%	70%	70%
Raingarden - 1"	90%	65%	58%
Swale	48%	30%	30%

References:

Comparative Pollutant Removal Capability of Stormwater Treatment Practices, Technical Note #95 from Watershed Protection Techniques. 2(4): 515-520, Article 64. Retrieved July 22, 2005 from the World Wide Web: http://www.stormwatercenter.net/Practice/64-Comparative%20Pollutant%20Removal.pdf

Choi, J & Engel, B. Urban BMPs and Cost Estimation, Structural BMP Expected Pollutant Removal Efficiency & Median Event Mean Concentration for Urban Land Uses. US EPA. (1993) Handbook Urban Runoff Pollution and Control Planning. Retrieved July 22, 2005 from the World Wide Web: http://danpatch.ecn.purdue.edu/~jychoi/ubmp0/emc2.htm

The Simple Method Loading Calculation and Reduction Calculation Worksheet (OS-4)

Design Consultants, Inc.

No.	Watershed Name	Landuse	Area (acres)	Sanded?	Sanded Area (acres)	% Impervious	Runoff (in)	Annual Runoff (cf)	Annual TSS (lbs)	Annual TP (lbs)	Annual TN (lbs)
1	Loc 7-Bioswale	Roadway/Parking Lot	0.11	Yes	0.11	80	33	13,041	540	0.41	2.4
2						0	0	0	0	0.00	0.0
3						0	0	0	0	0.00	0.0
4						0	0	0	0	0.00	0.0
5						0	0	0	0	0.00	0.0
6						0	0	0	0	0.00	0.0
7						0	0	0	0	0.00	0.0
8						0	0	0	0	0.00	0.0
9						0	0	0	0	0.00	0.0
10						0	0	0	0	0.00	0.0
11						0	0	0	0	0.00	0.0
12						0	0	0	0	0.00	0.0
13						0	0	0	0	0.00	0.0
14						0	0	0	0	0.00	0.0
15						0	0	0	0	0.00	0.0
Total			0		0			13,041	**540**	**0.4**	**2.4**

Landuse[1]	% Impervious	TSS (mg/l)	TP (mg/l)	TN (mg/l)
Commerical	85	75	0.2	2
Industrial	75	120	0.4	2.5
Multifamily	60	100	0.4	2.2
Open Urban Land	9	48.5	0.31	0.74
Residential-High Density	40	100	0.4	2.2
Residential-Low Density	10	100	0.4	2.2
Residential-Med. Density	30	100	0.4	2.2
Residential Roof	100	19	0.11	1.5
Roadway/Parking Lot	80	150	0.5	3

[1] High density residential (<1/4 acre lots); Medium density residential (1/4 to 1/2 acre lots); Low density residential (>1 acre lots); Multifamily (>7 dwellings per acre).

Annual Rainfall	48	inches; user specified
P_j	0.9	%; default
Sanding Rate	500	lbs/acre; default
Sanding Applications	10	times/year; default

Simple Method Equations:

L = 0.226 * R * C * A

Where:
L = Annual Load (lbs)
R = Annual Runoff (inches)
C = Pollutant Concentration (mg/l)
A = Area (acres)
0.226 = Unit Conversion Factor

$R = P * P_j * Rv$

Where:
R = Annual Runoff (inches)
P = Annual Rainfall (inches)
P_j = % of rainfall events producing runoff
Rv = Runoff Coefficient

Rv = 0.05+0.9 * Ia

Ia = Impervious Fraction (%)

References:

Pitt, Robert. (2004, February 16). The National Stormwater Quality Database (NSQD, version 1.1). Retrieved July 22, 2005 from the World Wide Web: http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/recentpaper.htm

The New York Stormwater Management Design Manual Appendix A. Retrieved July 22, 2005 from the World Wide Web: http://www.dec.state.ny.us/website/dow/toolbox/simple.pdf

The Simple Method to Calculate Urban Stormwater Loads. Retrieved July 22, 2005 from the World Wide Web: http://www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm

The Simple Method Loading Calculation and Reduction Calculation Worksheet (OS-4)

Design Consultants, Inc.

No.	Watershed Name	BMP Type	BMP Drainage Area (acres)	TSS Removal (%)	TP Removal (%)	TN Removal (%)	Annual TSS Removed (lbs)	Annual TP Removed (lbs)	Annual TN Removed (lbs)
1	Loc 7-Bioswale	Raingarden - 1"	0.108	90%	65%	58%	486	0.26	1.4
2							0	0.00	0.0
3							0	0.00	0.0
4							0	0.00	0.0
5							0	0.00	0.0
6							0	0.00	0.0
7							0	0.00	0.0
8							0	0.00	0.0
9							0	0.00	0.0
10							0	0.00	0.0
11							0	0.00	0.0
12							0	0.00	0.0
13							0	0.00	0.0
14							0	0.00	0.0
15							0	0.00	0.0
Total							**486**	**0.26**	**1.4**

BMP Type	TSS Removal (%)	TP Removal (%)	TN Removal (%)
Baffle Tank	70%	30%	0%
Constructed Wetland	80%	55%	30%
Detention Basin (dry)	48%	30%	30%
Infiltration - 1"	80%	70%	70%
Raingarden - 1"	90%	65%	58%
Swale	48%	30%	30%

References:

Comparative Pollutant Removal Capability of Stormwater Treatment Practices, Technical Note #95 from Watershed Protection Techniques. 2(4): 515-520, Article 64. Retrieved July 22, 2005 from the World Wide Web: http://www.stormwatercenter.net/Practice/64-Comparative%20Pollutant%20Removal.pdf

Choi, J & Engel, B. Urban BMPs and Cost Estimation, Structural BMP Expected Pollutant Removal Efficiency & Median Event Mean Concentration for Urban Land Uses. US EPA. (1993) Handbook Urban Runoff Pollution and Control Planning. Retrieved July 22, 2005 from the World Wide Web: http://danpatch.ecn.purdue.edu/~jychoi/ubmp0/emc2.htm

The Simple Method Loading Calculation and Reduction Calculation Worksheet (OS-6)

Design Consultants, Inc.

No.	Watershed Name	Landuse	Area (acres)	Sanded?	Sanded Area (acres)	% Impervious	Runoff (in)	Annual Runoff (cf)	Annual TSS (lbs)	Annual TP (lbs)	Annual TN (lbs)
1	Loc 10-Leaching	Roadway/Parking Lot	0.22	Yes	0.22	80	33	26,323	1,090	0.82	4.9
2	Loc 11-Leaching	Roadway/Parking Lot	0.09	Yes	0.09	80	33	11,109	460	0.35	2.1
3	Loc 12-Leaching	Roadway/Parking Lot	0.60	Yes	0.60	80	33	72,328	2,995	2.25	13.5
4	Loc 13-Bioswale	Roadway/Parking Lot	0.12	Yes	0.12	80	33	14,731	610	0.46	2.8
5	Loc 14-Leaching	Roadway/Parking Lot	0.16	Yes	0.16	80	33	19,078	790	0.59	3.6
6	Loc 15-Bioswale	Roadway/Parking Lot	0.19	Yes	0.19	80	33	22,701	940	0.71	4.2
7						0	0	0	0	0.00	0.0
8						0	0	0	0	0.00	0.0
9						0	0	0	0	0.00	0.0
10						0	0	0	0	0.00	0.0
11						0	0	0	0	0.00	0.0
12						0	0	0	0	0.00	0.0
13						0	0	0	0	0.00	0.0
14						0	0	0	0	0.00	0.0
15						0	0	0	0	0.00	0.0
Total			1		1			166,270	**6,885**	**5.2**	**31.1**

Landuse[1]	% Impervious	TSS (mg/l)	TP (mg/l)	TN (mg/l)
Commerical	85	75	0.2	2
Industrial	75	120	0.4	2.5
Multifamily	60	100	0.4	2.2
Open Urban Land	9	48.5	0.31	0.74
Residential-High Density	40	100	0.4	2.2
Residential-Low Density	10	100	0.4	2.2
Residential-Med. Density	30	100	0.4	2.2
Residential Roof	100	19	0.11	1.5
Roadway/Parking Lot	80	150	0.5	3

[1] High density residential (<1/4 acre lots); Medium density residential (1/4 to 1/2 acre lots); Low density residential (>1 acre lots); Multifamily (>7 dwellings per acre).

Annual Rainfall	48	inches; user specified
P_j	0.9	%; default
Sanding Rate	500	lbs/acre; default
Sanding Applications	10	times/year; default

Simple Method Equations:

L = 0.226 * R * C * A

Where:
L = Annual Load (lbs)
R = Annual Runoff (inches)
C = Pollutant Concentration (mg/l)
A = Area (acres)
0.226 = Unit Conversion Factor

$R = P * P_j * Rv$

Where:
R = Annual Runoff (inches)
P = Annual Rainfall (inches)
P_j = % of rainfall events producing runoff
Rv = Runoff Coefficient

Rv = 0.05+0.9 * Ia

Ia = Impervious Fraction (%)

References:

Pitt, Robert. (2004, February 16). The National Stormwater Quality Database (NSQD, version 1.1). Retrieved July 22, 2005 from the World Wide Web: http://unix.eng.ua.edu/~rpitt/Research/ms4/Paper/recentpaper.htm

The New York Stormwater Management Design Manual Appendix A. Retrieved July 22, 2005 from the World Wide Web: http://www.dec.state.ny.us/website/dow/toolbox/simple.pdf

The Simple Method to Calculate Urban Stormwater Loads. Retrieved July 22, 2005 from the World Wide Web: http://www.stormwatercenter.net/monitoring%20and%20assessment/simple%20meth/simple.htm

The Simple Method Loading Calculation and Reduction Calculation Worksheet (OS-6)

Design Consultants, Inc.

No.	Watershed Name	BMP Type	BMP Drainage Area (acres)	TSS Removal (%)	TP Removal (%)	TN Removal (%)	Annual TSS Removed (lbs)	Annual TP Removed (lbs)	Annual TN Removed (lbs)
1	Loc 10-Leaching	Infiltration - 1"	0.218	80%	70%	70%	872	0.57	3.4
2	Loc 11-Leaching	Infiltration - 1"	0.092	80%	70%	70%	368	0.24	1.5
3	Loc 12-Leaching	Infiltration - 1"	0.599	80%	70%	70%	2,396	1.58	9.5
4	Loc 13-Bioswale	Raingarden - 1"	0.122	90%	65%	58%	549	0.30	1.6
5	Loc 14-Leaching	Infiltration - 1"	0.158	80%	70%	70%	632	0.42	2.5
6	Loc 15-Bioswale	Raingarden - 1"	0.188	90%	65%	58%	846	0.46	2.5
7							0	0.00	0.0
8							0	0.00	0.0
9							0	0.00	0.0
10							0	0.00	0.0
11							0	0.00	0.0
12							0	0.00	0.0
13							0	0.00	0.0
14							0	0.00	0.0
15							0	0.00	0.0
Total							**5,663**	**3.56**	**20.9**

BMP Type	TSS Removal (%)	TP Removal (%)	TN Removal (%)
Baffle Tank	70%	30%	0%
Constructed Wetland	80%	55%	30%
Detention Basin (dry)	48%	30%	30%
Infiltration - 1"	80%	70%	70%
Raingarden - 1"	90%	65%	58%
Swale	48%	30%	30%

References:

Comparative Pollutant Removal Capability of Stormwater Treatment Practices, Technical Note #95 from Watershed Protection Techniques. 2(4): 515-520, Article 64. Retrieved July 22, 2005 from the World Wide Web: http://www.stormwatercenter.net/Practice/64-Comparative%20Pollutant%20Removal.pdf

Choi, J & Engel, B. Urban BMPs and Cost Estimation, Structural BMP Expected Pollutant Removal Efficiency & Median Event Mean Concentration for Urban Land Uses. US EPA. (1993) Handbook Urban Runoff Pollution and Control Planning. Retrieved July 22, 2005 from the World Wide Web: http://danpatch.ecn.purdue.edu/~jychoi/ubmp0/emc2.htm

Appendix C

RUSLE Calculations

> Home
> About RUSLE
> Erosion Factors
> Calculate Erosion
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RUSLE Factors

Both RUSLE and USLE can be expressed as follows:

A = R * K * LS * C * P

Where
A = estimated average soil loss in tons per acre per year
R = rainfall-runoff erosivity factor
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = cover-management factor
P = support practice factor

Another factor for soils is called "**T** value" which stands for "Tolerable Soil Loss." It is not directly used in RUSLE equation, but is often used along with RUSLE for conservation planning. Soil loss tolerance (T) is the maximum amount of soil loss in tons per acre per year, that can be tolerated and still permit a high level of crop productivity to be sustained economically and indefinitely.

Click on the links above to read the detail description of each factor.

> Home
> About RUSLE
> Erosion Factors
> Calculate Erosion
> Resources
> Contact Us
> Acknowledgement

LS Table for Construction Sites

The following table shows LS factors for freshly prepared constructed and other highly disturbed soil condition with little or no cover (not applicable to thawing soil)

Slope (%)	Slope Length (ft.)																
	<3	6	9	12	15	25	50	75	100	150	200	250	300	400	600	800	1000
0.2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06
0.5	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.10	0.11	0.12	0.12	0.13
1.0	0.09	0.09	0.09	0.09	0.09	0.10	0.13	0.14	0.15	0.17	0.18	0.19	0.20	0.22	0.24	0.26	0.27
2.0	0.13	0.13	0.13	0.13	0.13	0.16	0.21	0.25	0.28	0.33	0.37	0.40	0.43	0.48	0.56	0.63	0.69
3.0	0.17	0.17	0.17	0.17	0.17	0.21	0.30	0.36	0.41	0.50	0.57	0.64	0.69	0.80	0.96	1.10	1.23
4.0	0.20	0.20	0.20	0.20	0.20	0.26	0.38	0.47	0.55	0.68	0.79	0.89	0.98	1.14	1.42	1.65	1.86
5.0	0.23	0.23	0.23	0.23	0.23	0.31	0.46	0.58	0.68	0.86	1.02	1.16	1.28	1.51	1.91	2.25	2.55
6.0	0.26	0.26	0.26	0.26	0.26	0.36	0.54	0.69	0.82	1.05	1.25	1.43	1.60	1.90	2.43	2.89	3.30
8.0	0.32	0.32	0.32	0.32	0.32	0.45	0.70	0.91	1.10	1.43	1.72	1.99	2.24	2.70	3.52	4.24	4.91
10.0	0.35	0.37	0.38	0.39	0.40	0.57	0.91	1.20	1.46	1.92	2.34	2.72	3.09	3.75	4.95	6.03	7.02
12.0	0.36	0.41	0.45	0.47	0.49	0.71	1.15	1.54	1.88	2.51	3.07	3.60	4.09	5.01	6.67	8.17	9.57
14.0	0.38	0.45	0.51	0.55	0.58	0.85	1.40	1.87	2.31	3.09	3.81	4.48	5.11	6.30	8.45	10.40	12.23
16.0	0.39	0.49	0.56	0.62	0.67	0.98	1.64	2.21	2.73	3.68	4.56	5.37	6.15	7.60	10.26	12.69	14.96
20.0	0.41	0.56	0.67	0.76	0.84	1.24	2.10	2.86	3.57	4.85	6.04	7.16	8.23	10.24	13.94	17.35	20.57
25.0	0.45	0.64	0.80	0.93	1.04	1.56	2.67	3.67	4.59	6.30	7.88	9.38	10.81	13.53	18.57	23.24	27.66
30.0	0.48	0.72	0.91	1.08	1.24	1.86	3.22	4.44	5.58	7.70	9.67	11.55	13.35	16.77	23.14	29.07	34.71
40.0	0.53	0.85	1.13	1.37	1.59	2.41	4.24	5.89	7.44	10.35	13.07	15.67	18.17	22.95	31.89	40.29	48.29
50.0	0.58	0.97	1.31	1.62	1.91	2.91	5.16	7.20	9.13	12.75	16.16	19.42	22.57	28.60	39.95	50.63	60.84
60.0	0.63	1.07	1.47	1.84	2.19	3.36	5.97	8.37	10.63	14.89	18.92	22.78	26.51	33.67	47.18	59.93	72.15

(From: USDA Agricultural Handbook No. 703).

EPA United States Environmental Protection Agency

National Pollutant Discharge Elimination System (NPDES)

Rainfall Erosivity Factor Calculator for Small Construction Sites

EPA's stormwater regulations allow NPDES permitting authorities to waive NPDES permitting requirements for stormwater discharges from small construction sites if:

- the construction site disturbs less than five acres, and
- the rainfall erosivity factor ("R" in the revised universal soil loss equation, or RUSLE) value is less than five during the period of construction activity.

If your small construction project is located in an area where EPA is the permitting authority and your R factor is less than five, you qualify for a low erosivity waiver (LEW) from NPDES stormwater permitting. LEW certifications are submitted through the electronic Notice of Intent (eNOI) system. Several states that are authorized to implement the NPDES permitting program also accept LEWs. Check with your state NPDES permitting authority for more information.

- List of states, Indian country, and territories where EPA's 2012 Construction General Permit (CGP) and Multi-Sector General Permit (MSGP) Apply
- EPA's 2012 CGP eNOI System

The period during which small construction sites qualify for the waiver generally occurs during a relatively short time in arid and semi-arid areas. If your small construction project does not qualify for a waiver, then NPDES stormwater permit coverage is required.

To use the Rainfall Erosivity Factor Calculator to determine your eligibility for the LEW, you will need your project's location (either latitude/longitude or address) and the estimated start and end dates of construction. The period of construction activity begins at initial earth disturbance and ends with final stabilization.

- Construction Rainfall Erosivity Waiver Fact Sheet
- Appendix C of the 2012 CGP – Small Construction Waivers and Instructions

For questions or comments, email EPA's 2012 CGP staff at cgp@epa.gov.

Note: The calculator works best in Internet Explorer.

Facility Information

- Start Date: 1/1/2017
- End Date: 12/31/2017
- Address: Sturbridge, MA
- Latitude: 42.1084
- Longitude: -72.0787

Erosivity Index Calculator Results

An erosivity index value Of **135** has been determined for the construction period of **1/1/2017 - 12/31/2017**.

A rainfall erosivity factor of 5.0 or greater has been calculated for your site and period of construction. **You do NOT qualify for a waiver from NPDES permitting requirements**.

Start Over

Estimating Soil Loss Utilizing
Revised **U**niversal **S**oil **L**oss **E**quation **(RUSLE)**

Location 1 (OS-1)

A = R * K * LS * C * P

Where

A =	estimated average soil loss in tons per acre per year		
R =	rainfall-runoff erosivity factor =	135	
K =	soil erodibility factor =	0.1	
L =	slope length factor =	370	ft
S =	slope steepness factor =	3%	
LS =	length-slope factor =	0.77	
C =	cover-management factor (Bare soil) =	1	
P =	support practice factor(Bare Soil) =	1	

Annual Soil Loss in Tons/Acre/Year for Location 1 - Portion of Gravel Overflow Parking Area

A = 135 * 0.1 * 0.88 * 1 * 1 = 10.395 Tons/Acre/Year

Area = 22,663 SF = 0.520 Acres

Location 1 - Portion of Gravel Overflow Parking Area Soil Loss

= 5.408 Tons/Yr

= 10,816 Lbs/Yr

Estimating Soil Loss Utilizing
Revised **U**niversal **S**oil **L**oss **E**quation **(RUSLE)**

Location 2 (OS-2)

A = R * K * LS * C * P

Where

A =	estimated average soil loss in tons per acre per year		
R =	rainfall-runoff erosivity factor =	135	
K =	soil erodibility factor =	0.1	
L =	slope length factor =	500	ft
S =	slope steepness factor =	3%	
LS =	length-slope factor =	0.88	
C =	cover-management factor (Bare soil) =	1	
P =	support practice factor(Bare Soil) =	1	

Annual Soil Loss in Tons/Acre/Year for Location 2 - Gravel Overflow Parking Area

A = 135 * 0.1 * 0.88 * 1 * 1 = 11.88 Tons/Acre/Year

Area = 130,700 SF = 3.000 Acres

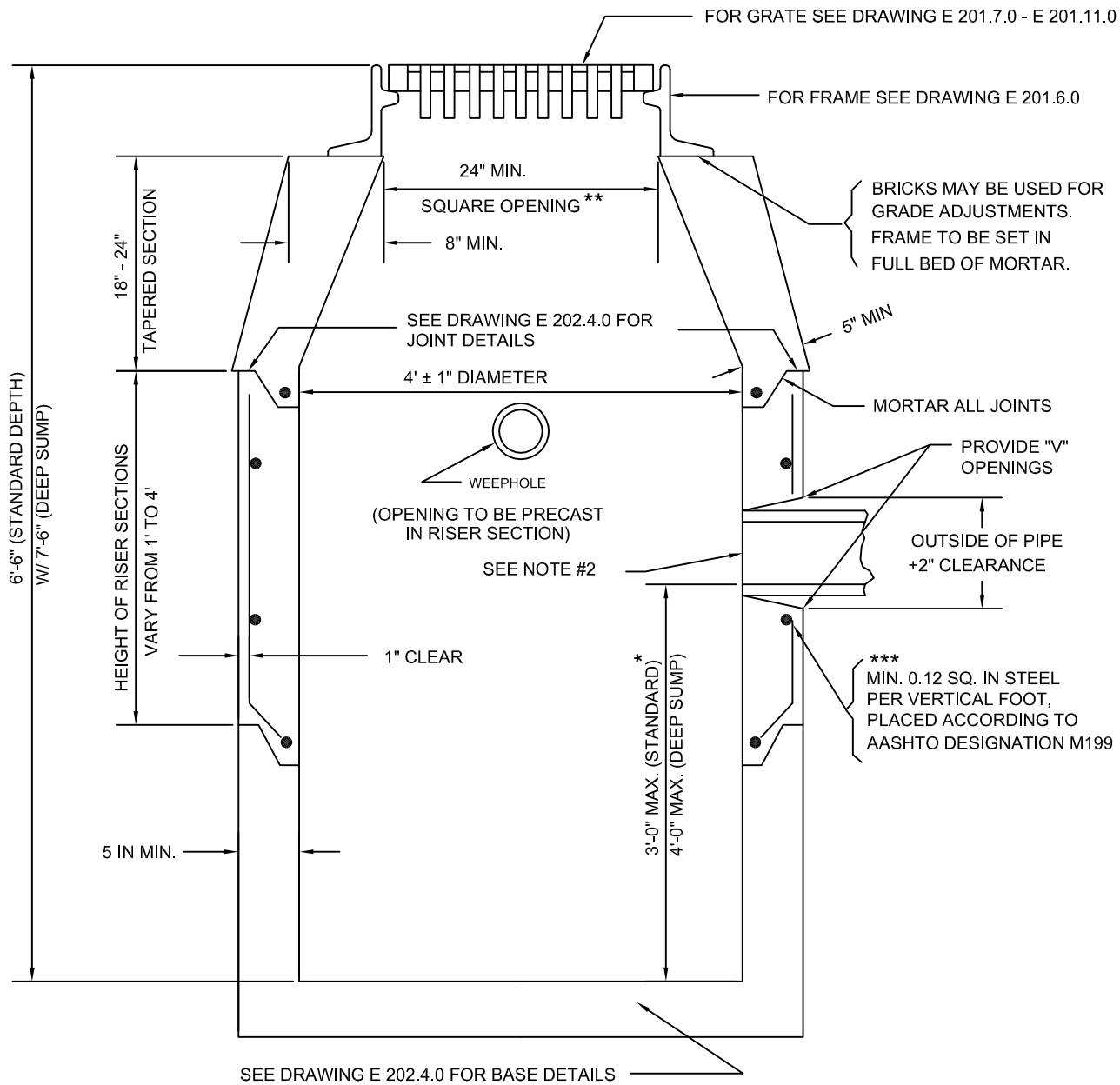
Location 2 - Gravel Overflow Parking Area Soil Loss

= 35.645 Tons/Yr

= 71,291 Lbs/Yr

Appendix D

BMP Designs



* MINIMUM DEPTH OF SUMP TO BE 2 FT

** WHEN A CURB INLET IS INSTALLED, THE OPENING IS TO BE 24"±1" X 27"±1"

*** REINFORCING STEEL BASED ON A WALL THICKNESS OF 5".

NOTES:

1. DETAILS NOT INDICATED ABOVE ARE TO BE SIMILAR TO THOSE SHOWN ON E 201.3.0
2. FACE OF PIPE FLUSH OR NOT TO PROJECT MORE THAN 4" FROM FACE OF WALL ALONG CENTERLINE OF PIPE.
3. FOR DESCRIPTION, MATERIALS AND CONSTRUCTION METHOD, SEE STANDARD SPECIFICATIONS.
4. ALL CONCRETE TO BE AIR ENTRAINED

massDOT Massachusetts Department of Transportation Highway Division

CONSTRUCTION STANDARDS

PRECAST CONCRETE CATCH BASIN

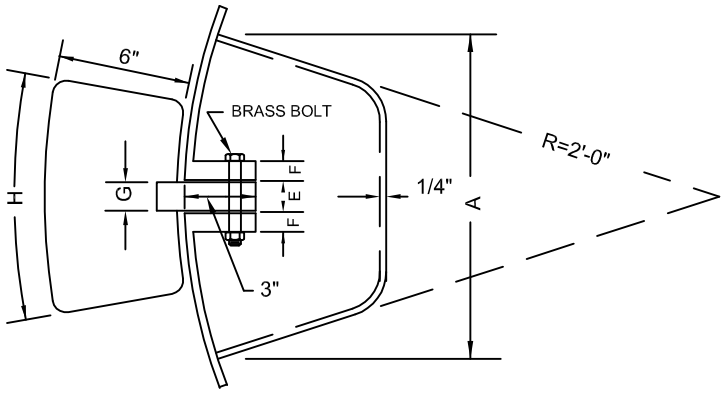
DATE OF ISSUE
JUNE 2014

DRAWING NUMBER
E 201.4.0

CONSTRUCTION STANDARDS

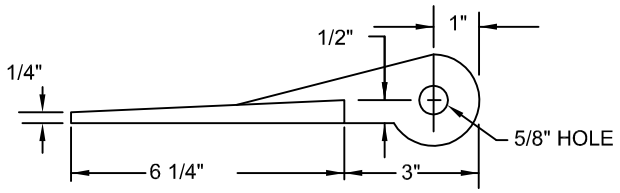
massDOT Massachusetts Department of Transportation Highway Division

CATCH BASIN HOOD

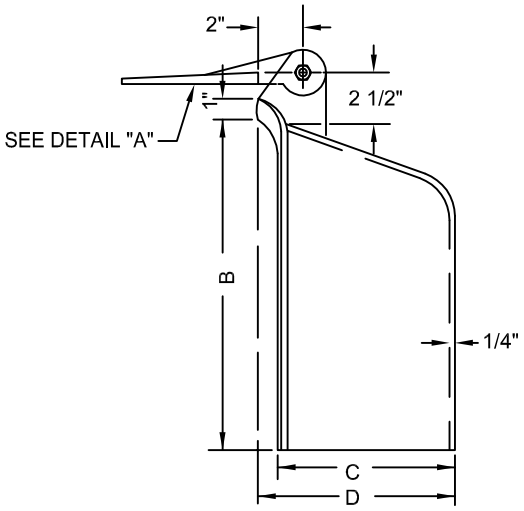


TOP

DIMENSIONS (in.)	A	B	C	D	E	F	G	H
8" and 10" PIPE	15	15	8	9	2	7/8	1 7/8	14
12" and 15" PIPE	18	18	10	11 1/4	2	1	1 7/8	14



DETAIL "A" HINGE



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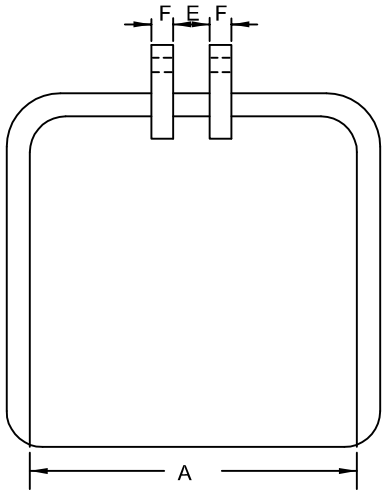

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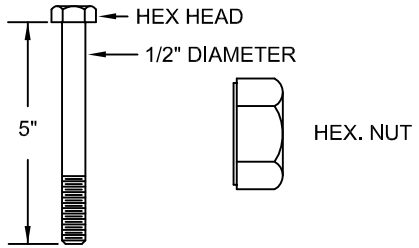


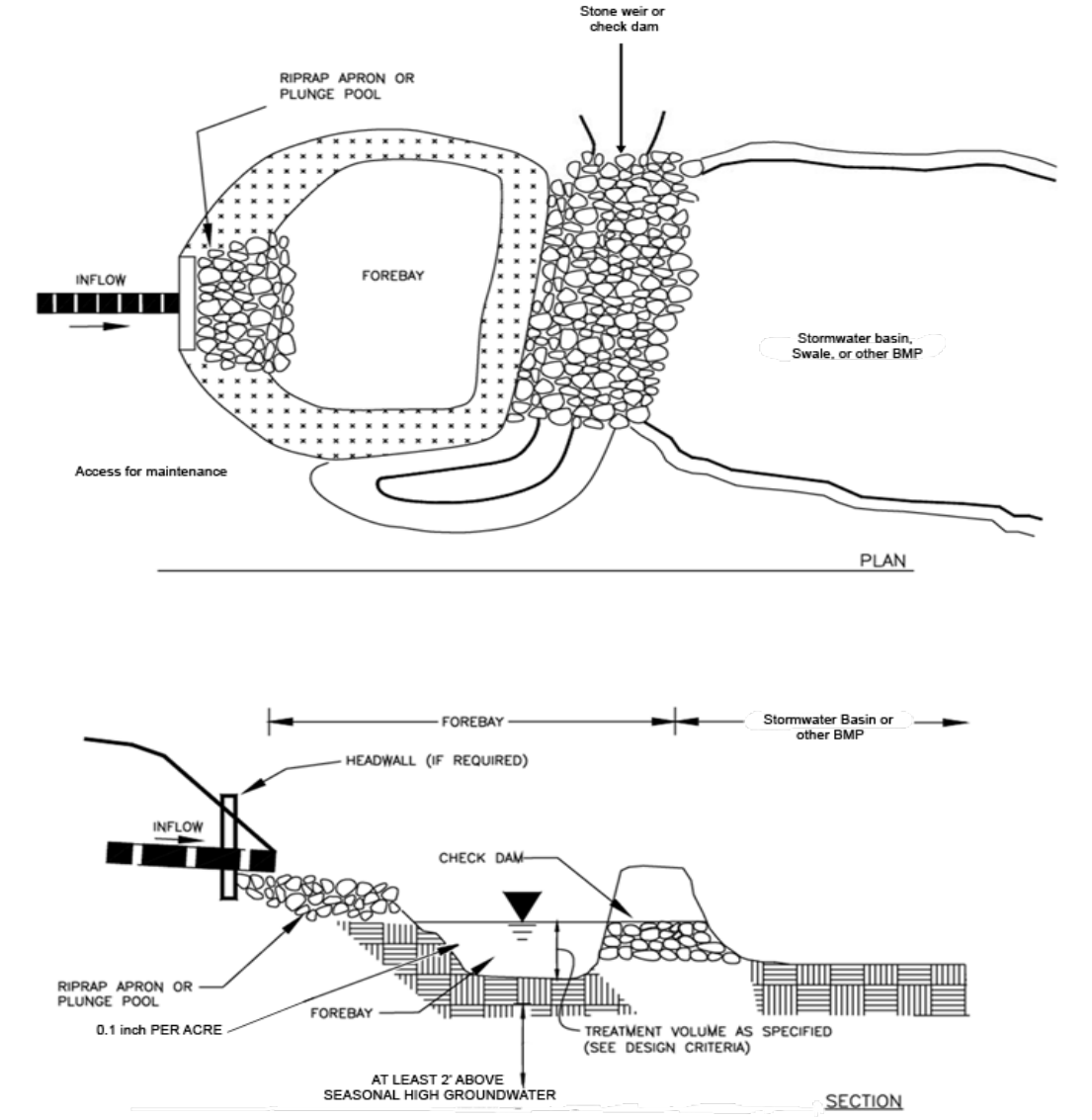
BRASS BOLT & NUT

NOTE:

1. HOODS TO BE GRAY CAST IRON - SEE STANDARD SPECIFICATIONS WITH NO BLACK ASPHALT COATING ALLOWED

DATE OF ISSUE
JUNE 2014

DRAWING NUMBER
E 201.12.0



adapted from the Vermont Stormwater Handbook

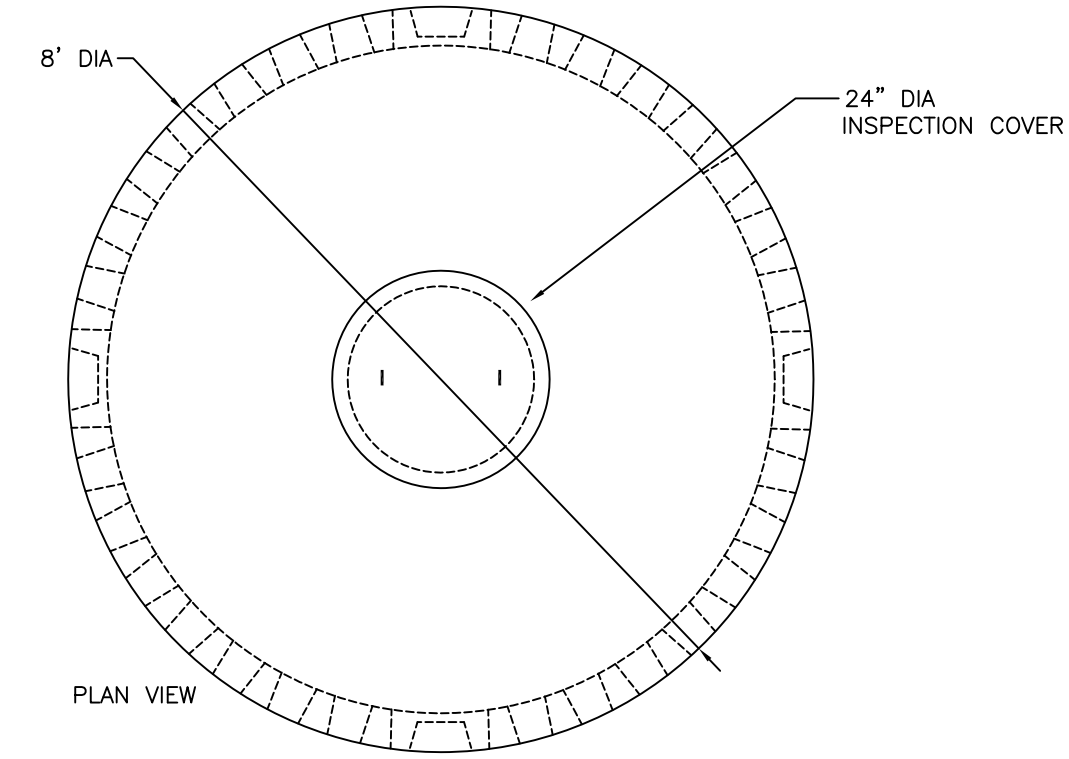
Maintenance

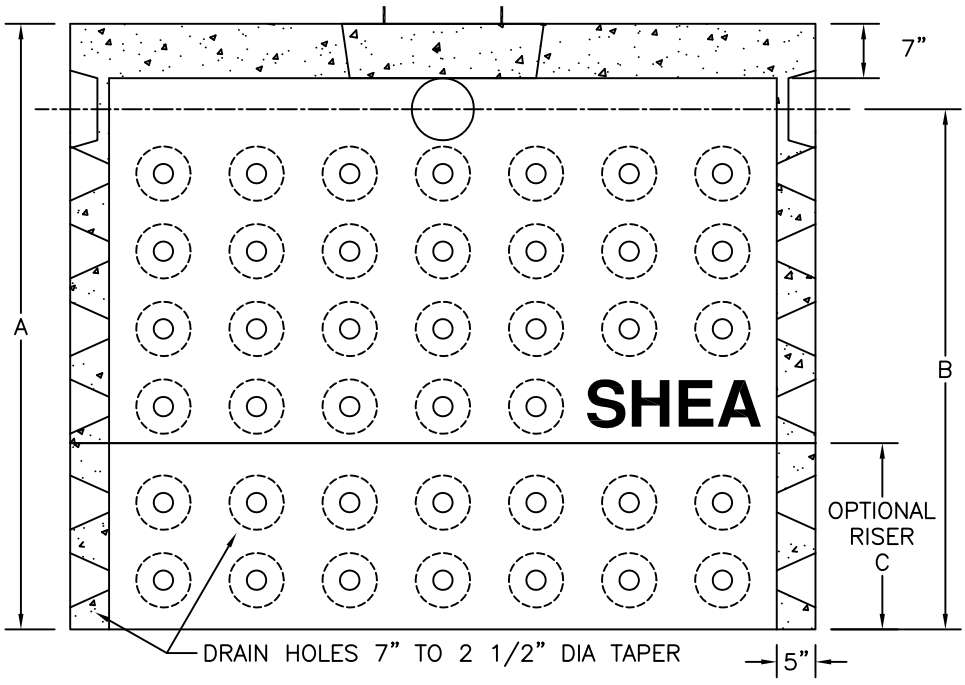
Activity	Frequency
Inspect sediment forebays	Monthly
Clean sediment forebays	Four times per year and when sediment depth is between 3 to 6 feet.

Special Features

MassDEP requires a sediment forebay as pretreatment before discharging to a dry extended detention basin, wet basin, constructed stormwater wetland, or infiltration basin.

MassDEP uses the term sediment forebay for BMPs used to pretreat stormwater after construction is complete and the site is stabilized. MassDEP uses the term sediment trap to refer to BMPs used for erosion and sedimentation control during construction. For information on the design and construction of sediment traps used during construction, consult the Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: A Guide for Planners, Designers and Municipal Officials.





SECTION VIEW

NOTES:

1. CONCRETE: 5,000 PSI MINIMUM AFTER 28 DAYS.
2. DESIGNED FOR H–20 LOADING, 1 TO 5 FEET OF COVER.

GALLONS	A (HGT)	B (CL)	ITEM NO.	WEIGHT
1000	4'–6"	3'–8"	TK–1000CDW	10,270#
1500	6'–2"	5'–4"	TK–1500CDW	12,503#
2200	9'–0"	8'–2"	1000+4'RISER	15,506#
2800	10'–8"	9'–10"	1000+6'RISER	18,230#

C	ITEM NO.	GALLONS	WEIGHT
4'–6"	TK–4RSCDW	1200	5,236#
6'–2"	TK–6RSCDW	1800	7,960#

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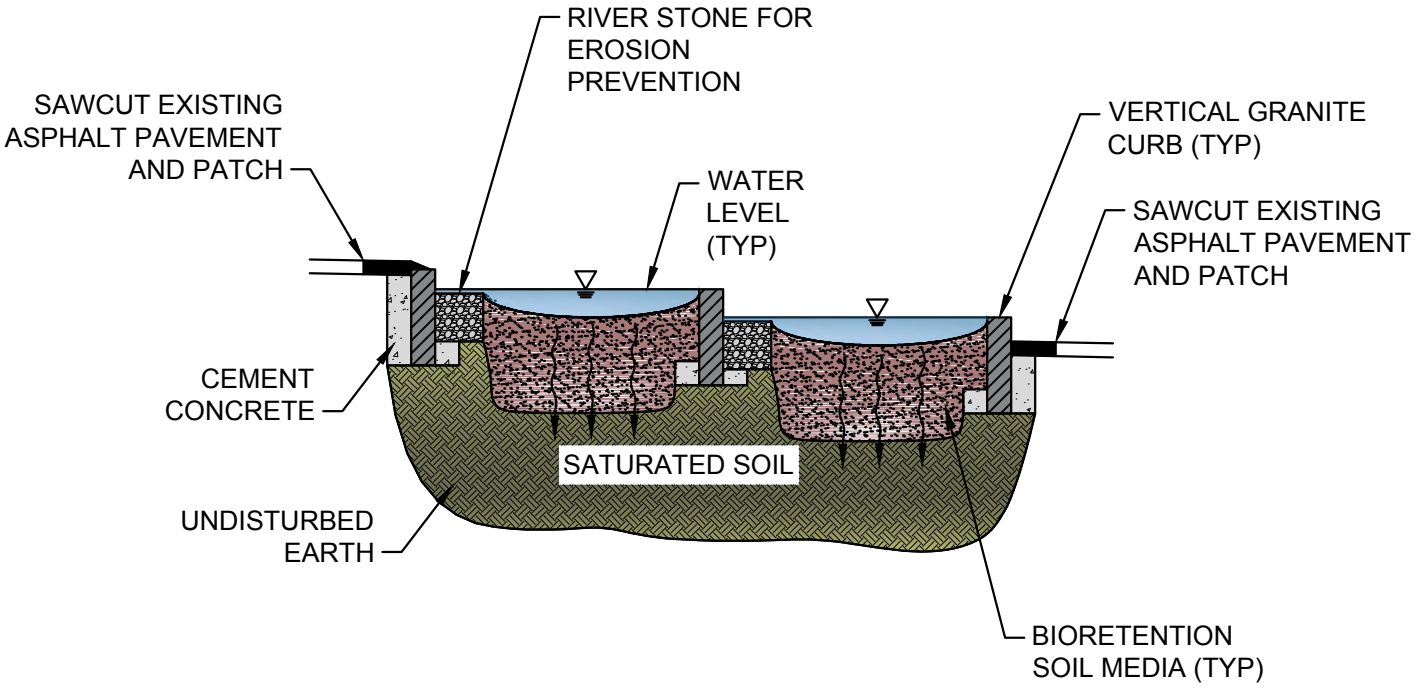
DRY WELL CYLINDRICAL 8' DIAMETER COMMERCIAL LINE

DW8Dia.dwg 11/30/2009

NPCA CERTIFIED PLANT



SCALE: 1" = 4'

Design Consultants, Inc.
CIVIL ENGINEERS and LAND SURVEYORS
120 Middlesex Avenue, Suite 20
Somerville, MA 02145
617-776-3350p 617-776-7710f

STORMWATER POLLUTION REDUCTION PROJECT
OLD STURBRIDGE VILLAGE, STURBRIDGE, MA

DATE: 10.06.16

TYPICAL BIORETENTION AREA-TYPE B

DCI PROJECT: 2016-055